

**DC POWER SUPPLY  
BENCH SERIES  
MODELS 6212B,  
6214B, 6216B, 6218B**





**HEWLETT  
PACKARD**

### **CERTIFICATION**

*Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.*

### **WARRANTY**

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

### **LIMITATION OF WARRANTY**

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

### **EXCLUSIVE REMEDIES**

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

### **ASSISTANCE**

*Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.*

*For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.*



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**OPERATING AND SERVICE MANUAL  
FOR SERIALS:**

**MODEL 6212B, 2240A-02411 AND ABOVE  
MODEL 6214B, 2238A-08181 AND ABOVE  
MODEL 6216B, 2236A-19951 AND ABOVE  
MODEL 6218B, 2236A-09831 AND ABOVE**

**\*For instrument with serial  
numbers above those listed a  
change page may be included.**

## SAFETY SUMMARY

*The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.*

### BEFORE APPLYING POWER.

Verify that the product is set to match the available line voltage and the correct fuse is installed.

### GROUND THE INSTRUMENT.

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the ac power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. For instruments designed to be hard-wired to the ac power lines (supply mains), connect the protective earth terminal to a protective conductor before any other connection is made. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earthed pole) of the ac power lines (supply mains).

### INPUT POWER MUST BE SWITCH CONNECTED.

For instruments without a built-in line switch, the input power lines must contain a switch or another adequate means for disconnecting the instrument from the ac power lines (supply mains).

### DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

### KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

### DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

### DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0 mA peak.

### SAFETY SYMBOLS.



Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).



Indicates hazardous voltages.



or



Indicate earth (ground) terminal.

**WARNING**

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

**CAUTION**

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

### DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

*Instruments which appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.*

# Section I

## GENERAL INFORMATION

### 1-1 DESCRIPTION

1-2 This power supply is completely transistorized and suitable for either bench or relay rack operation. It is a compact, well-regulated, Constant Voltage/Constant Current supply that will furnish full rated output voltage at the maximum rated output current or can be continuously adjusted throughout the output range. The front panel CURRENT control can be used to establish the output current limit (overload or short circuit) when the supply is used as a constant voltage source and the VOLTAGE controls can be used to establish the voltage limit (ceiling) when the supply is used as a constant current source. The supply will automatically crossover from constant voltage to constant current operation and vice versa if the output current or voltage exceeds these preset limits.

1-3 Either the positive or negative output terminal may be grounded or the power supply can be operated floating at up to a maximum of 300 volts off ground.

1-4 A single meter is used to measure either output voltage or output current in volts of mA. The voltage or current range is selected by the METER SELECTION switch on the front panel.

### 1-5 SPECIFICATIONS

1-6 Detailed specifications for the power supply are given in Table 1-1.

### 1-7 OPTIONS

1-8 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available for the instrument covered by this manual. Where necessary, detailed coverage of the options is included throughout the manual.

Option No.	Description
028	230 V, 50-400 Hz, Single-Phase Output. Factory modification consists of reconnecting the input transformer for 230 Vac operation. Refer to Section II for further details.

910 One additional operating and service manual shipped with the power supply.

### 1-9 ACCESSORIES

1-10 The accessories listed in the following chart may be ordered with the power supply or separately from your local Hewlett-Packard field sales office (refer to list at rear of manual for addresses).

HP Part No.	Description
14521B	3 1/2" High Rack Kit for mounting up to three BENCH supplies. (Refer to Section II for details.)

### 1-11 INSTRUMENT AND MANUAL IDENTIFICATION

1-12 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits of the prefix indicate the year (20 = 80, 21 = 81, etc.), the second two digits indicate the week, and the letter "A" designates the USA as the country of manufacture. The second part of the serial number is a different sequential number assigned to each power supply, starting with 00101.

1-13 If the serial number on your instrument does not agree with those on the title page of this manual, a yellow change sheet supplied with the manual defines the difference between your instrument and the instrument described by this manual.

### 1-14 ORDERING ADDITIONAL MANUALS

1-15 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP stock number provided on the title page.

## INPUT:

### 6212B

115 Vac,  $\pm 10\%$ , 48-440 Hz, 0.29A, 28W

### 6216B

115 Vac,  $\pm 10\%$ , 48-440 Hz, 0.25A, 26W

### 6214B

115 Vac,  $\pm 10\%$ , 48-440 Hz, 0.3A, 28W

### 6218B

115 Vac,  $\pm 10\%$ , 48-440 Hz, 0.25A, 26W

## OUTPUT:

### 6212A

0 to 100 Vdc, 0 to 0.1 A

### 6216B

0 to 25 Vdc, 0 to 0.4 A

### 6214B

0 to 10 Vdc, 0 to 1A

### 6218B

0 to 50 Vdc, 0 to 0.2 A

## LOAD REGULATION:

**Constant Voltage** – Less than 4 mV (8 mV, 6212B) for a load current change equal to the current rating of the supply.

**Constant Current** – Less than 500  $\mu$ A for a load voltage change equal to the voltage rating of the supply.

## LINE REGULATION:

**Constant Voltage** – Less than 4 mV for  $\pm 10\%$  change in the nominal line voltage at any output voltage and current within rating.

**Constant Current** – Less than 500  $\mu$ A for a  $\pm 10\%$  change in the normal line voltage at any output voltage and current within rating.

## RIPPLE AND NOISE:

**Constant Voltage** – Less than 200  $\mu$ V rms/1 mV p-p (dc to 20 MHz).

**Constant Current** – Less than 150  $\mu$ A p-p (dc to 20 MHz).

## TEMPERATURE RANGES:

**Operating:** 0° to 55° C.

**Storage:** -40° to +75° C.

## TEMPERATURE COEFFICIENT:

**Constant Voltage** – Less than 0.02% + 1 mV output change per degree centigrade change in ambient following 30 minutes warm-up.

**Constant Current** – Less than (see table) output change per degree centigrade change in ambient following 30 minutes warm-up.

6212A	–	0.5 mA
6214B	–	6 mA
6216B	–	2 mA
6218B	–	1 mA

## STABILITY:

**Constant Voltage** – Less than 0.1% + 5 mV total drift for 8 hours following 30 minutes warm-up at constant ambient, constant line voltage, and constant load.

**Constant Current** – Less than (see table) total drift for 8 hours following 30 minutes warm-up at constant ambient, constant line voltage, and constant load.

6212B	–	1.3 mA
6214B	–	15 mA
6216B	–	5 mA
6218B	–	2.5 mA

## TRANSIENT RECOVERY TIME:

Less than 50  $\mu$ sec for output voltage recovery in constant voltage operation to within 15 mV of the nominal output voltage following a change in output current equal to the current rating of the supply.

## OVERLOAD PROTECTION:

A fixed current limiting circuit protects the power supply for all overloads including a direct short circuit placed across the output terminals in constant voltage operation.

## METER:

The front panel meter can be used as a voltmeter or an ammeter.

## OUTPUT CONTROLS:

Concentric coarse and fine voltage controls and concentric coarse and fine current controls set desired output voltage/current. Meter switch selects voltage or current.

## OUTPUT TERMINALS:

Three "five-way" output terminals are provided on the front panel. They are isolated from the chassis and either the positive or negative terminal may be connected to the chassis through a separate ground terminal.

## COOLING:

Convection cooling is employed. The supply has no moving parts.

## SIZE:

See Figure 2-1.

## WEIGHT:

4.75 lbs./1,2 kg. net, 6.75 lbs./3,1 kg. shipping.

## FINISH:

Dark gray.

## POWER CORD:

A 3-wire, 5 foot (1,52 cm) power cord is provided with each unit.

## Section II INSTALLATION

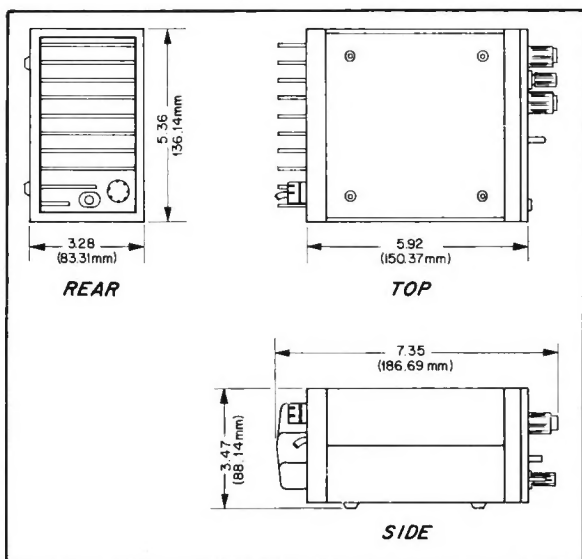


Figure 2-1. Outline Diagram

### 2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, file claim with carrier immediately. Hewlett-Packard Sales and Service office should be notified as soon as possible.

### 2-3 Mechanical Check

2-4 This check should confirm that there are no

broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or cracked.

### 2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

### 2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the instrument to a source of power and it is ready operation.

### 2-9 Location

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the rear of the instrument when it is in operation. It should be used in an area where the ambient temperature does not exceed 55° C.

### 2-11 Outline Diagram

2-12 Figure 2-1 illustrates the outline shape and dimensions of Models 6211B through 6218B.

### 2-13 Rack Mounting

2-14 This instrument may be rack mounted separately or with a maximum of two other BENCH Series supplies as shown in Figure 2-2. The units are placed in the Rack Mounting Frame. The Rack Mounting Frame is then fastened to the rack frame.



Figure 2-2. Rack Kit with three BENCH supplies.

2-15 INPUT POWER REQUIREMENTS

2-16 This power supply may be operated continuously from either a nominal 115 volt or 230 volt 50-400 Hz power source. The unit as shipped from the factory, is wired for 115 volt operation. The input power required when operated from a 115 volt power source at full load is:

Model	Input Current	Input Power
6212B	0.29A	28W
6214B	0.29A	28W
6217B	0.25A	26W
6218B	0.25A	26W

2-17 Connections for 230 Volt Operation (Figure 2-3)

2-18 Normally, the two primary windings of the input transformer are connected in parallel for operation from 115 volt source. To convert the power supply to operation from a 230 volt source, the power transformer windings are connected in series as follows:

- a. Unplug the line cord and remove the top cover as described in Paragraph 5-3.
- b. Remove the jumpers between taps 4-2 and 3-1. Solder a jumper between taps 3-2 on the input power transformer T1, see Figure 2-3.
- c. Replace existing fuse with 0.5 ampere, 230 volt fuse.
- d. Replace existing line cord plug with a standard 230 volt plug.

2-19 Power Cable

2-20 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. The third conductor is the ground conduc-

tor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection.

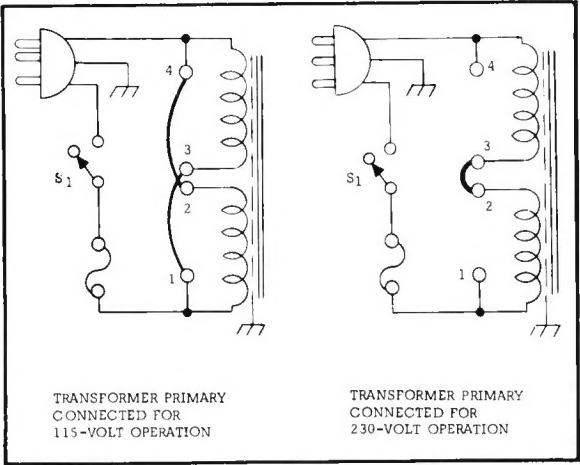


Figure 2-3. Input Power Transformer, Connections

2-21 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to ground.

2-22 REPACKAGING FOR SHIPMENT

2-23 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.



## Section III

# OPERATING INSTRUCTIONS

### 3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure describes the use of the front panel control and indicators illustrated in Figure 3-1 and ensures that the supply is operational:

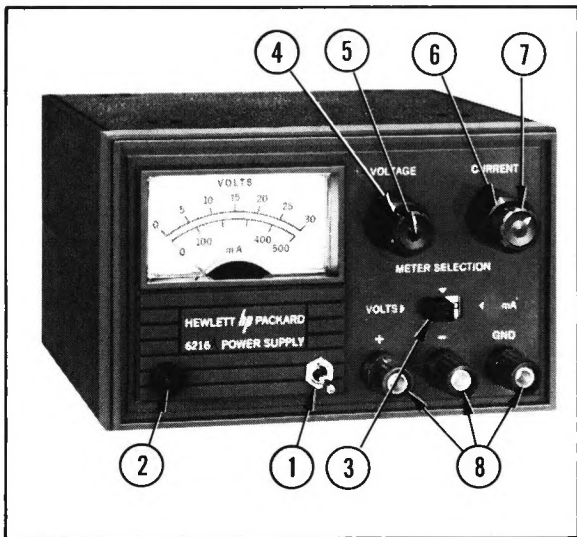


Figure 3-1. Front Panel Controls and Indicators.

- Set AC toggle switch (1) upward to on position; indicator (2) should light.
- Set METER SELECTION switch (3) to VOLTS position.
- Turn coarse (4) and fine (5) VOLTAGE controls fully ccw to ensure that output decreases to 0V, then turn the VOLTAGE controls fully cw to ensure that output voltage increases to the maximum rated output voltage.
- Set METER SELECTION switch (3) to mA position and short circuit (+) and (-) output terminals.
- Turn coarse (6) and fine (7) CURRENT controls fully ccw and then fully cw to ensure that the output current reaches zero and maximum rated output.
- Remove short and connect load to output terminals.

### 3-3 OPERATION

3-4 The power supply can be operated as a single unit (normal operation), in parallel, or in series. The output of the supply can be floated up to 300 volts off ground.

### 3-5 Constant Voltage

3-6 To select a constant voltage output, proceed as follows:

- Turn-on power supply and adjust VOLTAGE controls for desired output voltage (output terminals open).
- Short output terminals and adjust CURRENT controls for maximum output current allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically crossover to constant current output at the present current limit and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak current which can cause unwanted cross-over. (Refer to paragraph 3-20).

### 3-7 CONSTANT CURRENT

3-8 To select a constant current output, proceed as follows:

- Short output terminals and adjust CURRENT controls for desired output current.
- Open output terminals and adjust VOLTAGE controls for maximum output voltage allowable (voltage limit), as determined by load conditions. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit and the output current will drop proportionately. In setting the voltage limit, allowance must be made for high peak voltages which can cause unwanted crossover. (Refer to paragraph 3-20).

### 3-9 CONNECTING LOADS

3-10 Each load should be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If shield is used, connect one end to power supply ground terminal and leave the other end unconnected.)

**3-11** If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals.

### **3-12 Operation of Supply Beyond Rated Output.**

**3-13** The shaded area on the front panel meter face indicates the amount of output voltage or current that is available in excess of the normal rated output. Although the supply can be operated in this shaded region without being damaged, it cannot be guaranteed to meet all of its performance specifications. However, if the line voltage is maintained above 115 Vac, the supply will probably operate within its specifications.

## **3-14 OPTIONAL OPERATING MODES**

### **3-15 Series Operation**

**3-16 Normal Series Connections.** Two or more power supplies can be operated in series to obtain a higher voltage than that available from a single supply. When this connection is used, the output voltage is the sum of the voltages of the individual supplies. Each of the individual supplies must be adjusted in order to obtain the total output voltage. The power supply contains a protective diode connected internally across the output which protects the supply if one power supply is turned off while its series partner(s) is on.

### **3-17 Parallel Operation**

**3-18** Two or more power supplies can be connected in parallel to obtain a total output current greater than that available from one power supply. The total output current is the sum of the output currents of the individual power supplies. The output of each power supply can be set separately. The output voltage controls of one power supply should be set to the desired output voltage; the other power supply should be set for a slightly larger output voltage. The supply set to the lower output voltage will act as a constant voltage source; the supply set to the higher output will act as a current limit source, dropping its output voltage until it equals that of the other supply. The constant voltage source will deliver only that fraction of its total rated output current which is necessary to fulfill the total current demand.

## **3-19 SPECIAL OPERATING CONSIDERATIONS**

### **3-20 Pulse Loading**

**3-21** The power supply will automatically cross over from constant-voltage to constant-current operation in response to an increase (over the preset limit) in the output current. Although the preset limit may be set higher than the average output current, high peak currents (as occur in pulse loading) may exceed the preset current limit and cause crossover to occur. If this crossover limiting is not desired, set the preset limit for the peak requirement and not the average.

### **3-22 Output Capacitance**

**3-23** An internal capacitor, across the output terminals of the power supply, helps to supply high-current pulses of short duration during constant voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the safety provided by the current limiting circuit. A high-current pulse may damage load components before the average output current is large enough to cause the current limiting circuit to operate.

### **3-24 Reverse Current Loading**

**3-25** Active loads connected to the power supply may actually deliver a reverse current to the power supply during a portion of its operating cycle. An external source cannot be allowed to pump current into the supply without loss of regulation and possible damage to the output capacitor. To avoid these effects, it is necessary to preload the supply with a dummy load resistor so that the power supply delivers current through the entire operating cycle of the load device.

**3-26 Reverse Voltage Protection.** A diode is connected across the output terminals with reverse polarity. This diode protects the output electrolytic capacitors and the series regulator transistors from the effects of a reverse voltage applied across the output terminals. For example, in series operation of two supplies, if the AC is removed from one supply, the diode prevents damage to the unenergized supply which would otherwise result from a reverse polarity voltage.

**3-27** Since series regulator transistors or driver transistors cannot withstand reverse voltage, another diode is connected across the series transistor. This diode protects the series transistors in parallel or Auto-Parallel operation if one supply of the parallel combination is turned on before the other.

## Section IV PRINCIPLES OF OPERATION

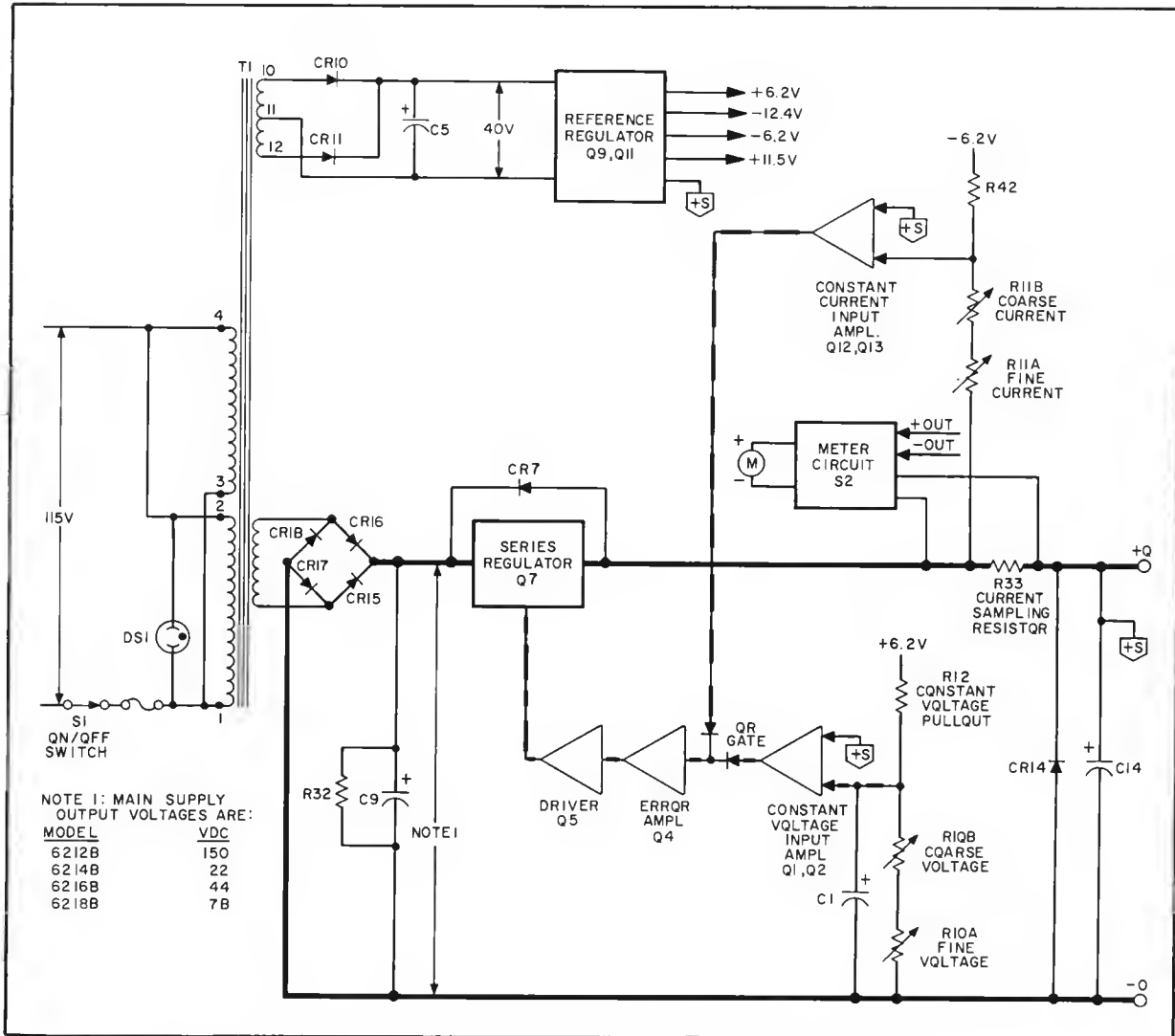


Figure 4-1. Block Diagram.

### 4-1 OVERALL DESCRIPTION

4-2 The major circuits of the power supply are shown on the overall block diagram, Figure 4-1.

4-3 The input AC line voltage is stepped down by the power transformer and applied to the rectifier and filter. The rectifier-filter converts the AC input to raw DC which is fed to the positive output terminal via series regulator Q7 and current sampling resistor R33. The regulator, part of the feedback loop, is made to alter its conduction to maintain a constant output voltage or current. The

voltage developed across the current sampling resistor is the input to the constant current amplifier. The constant voltage input amplifier obtains its input by sampling the output voltage of the supply.

4-4 Any changes in output voltage or current are detected in the constant voltage or constant current input circuit, amplified by the error amplifier, and driver and applied to the series regulator in the correct phase and amplitude to counteract the change in output voltage or current.

4-5 Two input amplifiers are included in a CV/CC

supply, one for controlling output voltage, the other for controlling output current. Since the constant voltage amplifier tends to achieve zero output impedance and alters the output *current* whenever the load resistance changes, while the constant current comparison amplifier causes the output impedance to be infinite and changes the output *voltage* in response to any load resistance change, it is obvious that the two comparison amplifiers cannot operate simultaneously. For any given value of load resistance, the power supply must act either as a constant voltage source or as a constant current source—it cannot be both; transfer between these two modes is accomplished at a value of load resistance equal to the ratio of the output voltage control setting to the output current control setting.

4-6 Figure 4-2 shows the output characteristic of a CV/CC power supply. With no load attached ( $R_L = \infty$ ),  $I_{OUT} = 0$ , and  $E_{OUT} = E_S$ , the front panel voltage control setting. When a load resistance is applied to the output terminals of the power supply, the output current increases, while the output voltage remains constant; point D thus represents a typical constant voltage operating point. Further decreases in load resistance are accompanied by further increases in  $I_{OUT}$  with no change in the output voltage until the output current reaches  $I_S$ , a value equal to the front panel current control setting. At this point the supply automatically changes its mode of operation and becomes a constant current source; still further decreases in value of load resistance are accompanied by a drop in the supply output voltage with no accompanying change in the output current value. Thus, point B represents a typical constant current operating point. Still further decreases in the load resistance result

in output voltage decreases with no change in output current, until finally, with a short circuit across the output load terminals,  $I_{OUT} = I_S$  and  $E_{OUT} = 0$ .

4-7 By gradually changing the load resistance from a short circuit to an open circuit the operating locus of Figure 4-2 will be traversed in the opposite direction.

Full protection against any overload condition is inherent in the Constant Voltage/Constant Current design principle since there isn't any load condition that can cause an output which lies outside the operating locus of Figure 4-2. Whether one is primarily concerned with constant voltage or constant current operation, the proper choice of  $E_S$  and  $I_S$  insures optimum protection for the load device as well as full protection for the power supply itself.

4-8 The line connecting the origin with any operating point of the locus of Figure 4-2 has a slope which is proportional to the value of load resistance connected to the output terminals of the supply. One can define a "critical" or "crossover" value of load resistance  $R_C = E_S / I_S$ ; adjustment of the front panel voltage and current controls permits this "crossover" resistance  $R_C$  to be set to any desired value from 0 to  $\infty$ . If  $R_L$  is greater than  $R_C$ , the supply is in constant voltage operation, while if  $R_L$  is less than  $R_C$ , the supply is in constant current operation.

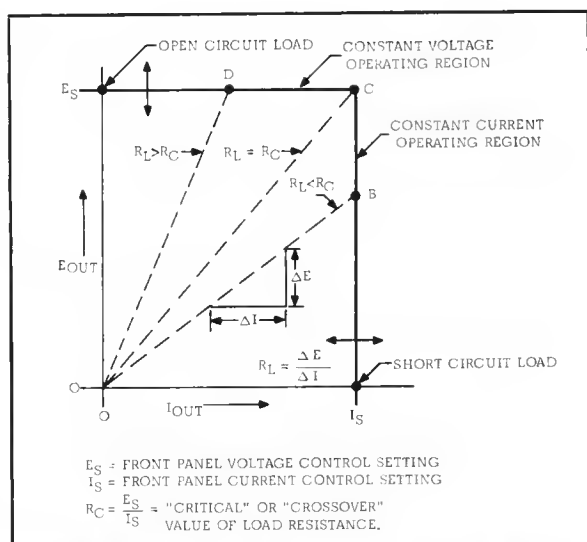
4-9 The reference circuit provides stable reference voltages which are used by the constant voltage/current input circuits for comparison purposes. The meter circuit provides an indication of output voltage or current for both operating modes.

4-10 Diode CR14 is connected across the output terminals in reverse polarity. It protects the output electrolytic capacitor and the series regulator transistor from the effects of a reverse voltage applied across the output terminals. For example, in series operation of two supplies, if the AC is removed from one supply, the diode prevents damage to the unenergized supply.

## 4-11 DETAILED CIRCUIT ANALYSIS (Refer to Figures 7-1 and 7-2, Schematic Diagram)

## 4-12 Feedback Loop

4-13 The feedback loop functions continuously to keep the output voltage constant during constant voltage operation, and the output current constant during constant current operation. For purposes of this discussion, assume that the unit is in constant voltage operation and that the programming resistors R10A and B have been adjusted so that the supply is yielding the desired output voltage. Further assume that the output voltage instan-



**Figure 4-2. Operating Locus of a Cycle Power Supply.**

taneously rises (increases) due to a variation (decrease) in the external load circuit.

4-14 Note that the change may be in the form of a slow rise in the output voltage or a positive going AC signal. An AC signal is coupled to Q1 through capacitor C1 and a DC voltage is coupled to Q1 through R10.

4-15 The increase in output voltage causes the voltage at the base of Q1 to decrease (go negative). Q1 now decreases its conduction and its collector voltage rises. The positive going error voltage is amplified and inverted by Q4 and fed to the base of series transistor Q7 via emitter follower Q5. The negative going input causes Q7 to decrease its conduction so that it drops more of the supply voltage, and reduces the output voltage to its original level. (6212B only, zener diode VR9 limits the voltage swing across Q5 and Q7 and, thus, minimizes the dissipation of Q5).

4-16 If the external load resistance is decreased to a certain crossover point as discussed in Paragraph 4-6 the output current increases until transistor Q12 begins to conduct. During this time, the output voltage has also decreased to a level so that the base of Q1 is at a high positive potential. With Q1 in full conduction, its collector voltage decreases by the amount necessary to back bias OR gate diode CR5 and the supply is now in the constant current mode of operation. The operation of the feedback loop during the constant current operating mode is similar to that occurring during constant voltage operation except that the input to the constant current input amplifier is obtained from the current sampling resistor R33.

**4-17 Series Regulator**

4-18 The series regulator consists of transistor stage Q7 (see schematic at rear of manual). The regulator serves as a series control element by altering its conduction so that the output voltage or current is kept constant. The conduction of the transistor is controlled by the feedback voltage obtained from the error amplifier. Diode CR7 protects the series transistor against reverse voltages that could develop during parallel operation, if one supply is turned on before the other.

**4-19 Constant Voltage Input Amplifier**

4-20 This circuit consists of programming resistor R10A and B, and a differential amplifier stage (Q1, Q2, and associated components). The constant voltage input amplifier continuously compares a fixed reference voltage with a portion of the output voltage and, if a difference exists, produces an error voltage whose amplitude and phase is proportional to the difference. The error output is fed back to the series regulator, through

an OR gate and the driver and error amplifiers. The error voltage changes the conduction of the series regulator which, in turn, alters the output voltage so that the difference between the two input voltages applied to the differential amplifier is reduced to zero. The above action maintains the output voltage constant.

4-21 Stage Q2 of the differential amplifier is connected to a common (+S) potential through impedance equalizing resistor R6. Resistor(s) Z1B (and R2, for the 6212B) are used to zero bias the input stage, offsetting minor base-to-emitter voltage differences in Q1 and Q2. The base of Q1 is connected to a summing point at the junction of the programming resistor and the current pullout resistor, R12. Instantaneous changes in output voltage result in an increase or decrease in the summing point potential. Q1 is then made to conduct more or less, in accordance with the summing point voltage change. The resultant output error voltage is fed back to the series regulator via OR-gate diode CR5 and the remaining components of the feedback loop. Resistor R1, in series with the base of Q1, limits the current through the programming resistor during rapid voltage turn-down. Diodes CR1 and CR2 form a limiting network which prevent excessive voltage excursions from over driving stage Q1. Capacitor C1, shunting the programming resistors increases the high frequency gain of the input amplifier.

**4-22 Constant Current Input Amplifier**

4-23 This circuit is similar in appearance and operation to the constant voltage input circuit. It consists basically of the current programming resistors R11A and B, and a differential amplifier stage (Q12, Q13, and associated components).

4-24 The constant current input amplifier continuously compares a fixed reference voltage with the voltage drop across current sampling resistor R33. If a difference exists, The differential amplifier produces an error voltage which is proportional to this difference. The remaining components in the feedback loop (amplifiers and series regulator) function to maintain the drop across the current sampling resistor, and consequently the output current, at a constant value. R14 and R57 compensate for the current drawn by the meter when in constant current mode by drawing an equivalent amount of current when output is shorted for current setting thus assuring proper current to load.

4-25 Stage Q13 is connected to a common (+S) potential through impedance equalizing resistor R43. Resistor Z1G is used to zero bias the input stage, offsetting minor base-to-emitter voltage differences in Q12 and Q13. Instantaneous changes in output current on the positive line are felt at the base of Q12. Stage Q12 varies its conduction in accordance with the polarity of the

change at the summing point. The change in conduction of Q12 also varies the conduction of Q13 due to the coupling effects of the common emitter resistor Z1H. The error voltage is taken from the collector of Q13 and fed back to the series regulator through OR-gate diode CR6 and the remaining components of the feedback loop. The error voltage then varies the conduction of the regulator so that output current is maintained at the proper level.

4-26 Capacitor C4, in conjunction with Z1K helps stabilize the feedback loop. Diode CR20 limits voltage excursions on the base of Q12.

## 4-27 Voltage Clamp Circuit

4-28 During constant current operation the constant voltage programming resistors R10A and B are a shunt load across the output terminals of the power supply. If the output voltage varies, the current through these resistors would tend to change resulting in an output current change. The clamp circuit is a return path for the voltage programming current, the current that normally flows through the programming resistors. The circuit maintains the current into the base of Q1 constant, thus eliminating the error due to shunting effects of the constant voltage programming resistors.

4-29 The voltage divider, Z1E, Z1F, and VR2 back biases CR3 and Q3 during constant voltage operation. When the power supply goes into constant current operation, CR3 becomes forward biased by the collector voltage of Q1. This results in conduction of Q3 and the clamping of the summing point at a potential only slightly more negative than the normal constant voltage potential. Clamping this voltage at approximately the same potential that exists in constant voltage operation, results in a constant voltage across, and consequently a constant current through pullout resistor R12.

## 4-30 Driver and Error Amplifier

4-31 The error and driver amplifiers amplify the error signal from the constant voltage input circuit to a level sufficient to drive the series regulator transistor. Amplifier Q4 also receives a current limiting input if CR6, the current limiting diode, becomes forward biased.

4-32 Stage Q4 contains a feedback equalizer network, C3 and R17, which provides for high frequency roll off in the loop gain in order to stabilize the feedback loop.

## 4-33 Reference Regulator Circuit

4-34 The reference regulator circuit is a separate power supply similar to the main supply. It provides stable reference voltages which are used throughout the unit. The reference voltages are all derived from smoothed dc obtained from the full wave rectifier (CR10 and CR11) and filter capacitor C5. The  $-6.2$  V and  $-12.4$  V reference voltages are derived from VR1 which is a second dc source regulating at 12.4 Vdc. Current for VR1 is supplied by the (–) side of C5 and flows through VR1, the base-emitter junction of Q7, R20, and back to the positive side of C5.

4-35 The base-emitter junction of Q11 is held constant by 6.2 V zener diode VR7 which regulates line voltage changes that alter the voltage across C5. Thus Q11 is a constant current source feeding 7.5 V zener diode VR4, 4 V diode VR5, and 6.2 V temperature-compensated zener diode VR6.

4-36 Resistors R30 and VR8 form a voltage divider across the stable 12.4 volts developed by VR1. The base-emitter junction of Q9 is therefore held constant by the voltage developed across VR8. Thus Q9 provides a constant current to zener diode R3 which regulates the  $-6.2$  V source.

## 4-37 Meter Circuit

4-38 This circuit provides indication of output voltage or current. With METER SELECTION switch S2 set to V position, the meter is in series with R54, and R52 across the output of the supply.

4-39 With METER SELECTION switch S2 set to mA position, the meter is connected in series with R52 and R53 across current sampling resistor R33. CURRENT ADJ potentiometer R52 is adjusted for full scale deflection with a full load connected to the output terminals. Resistors R55, R14, and R57 are connected across the current sampling resistor R33 when S2 is set to V position. It prevents the current sampling resistor from indicating an erroneous current by simulating the meter circuit, which is connected across the current sampling resistor in the current mode.

# Section V MAINTENANCE

## 5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance check (Paragraph 5-8) should be made. This check is suitable for incoming inspection. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-57). After troubleshooting and repair (Paragraph 5-65), perform any necessary adjustments and calibrations (Paragraph 5-67). Before returning the power supply to normal operation, repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist.

## 5-3 COVER REMOVAL AND REPLACEMENT

5-4 To remove the top and bottom covers, proceed as follows:

- Insert a small screwdriver in each of the four notches at the front of the unit at the top and bottom. Push the screwdriver under the front panel and gently pry toward the front of the unit to release the holding mechanism.
- Pull the front panel forward until it clears

the top and bottom covers.

- Remove the rear cover by repeating step a.
- Pull the rear cover until it clears the top and bottom covers. Then lift off the top cover and lift out the bottom cover.

5-5 To replace the top and bottom cover, proceed as follows:

- Place the unit into the bottom cover (identified by the four protruding feet) and align the heat sink into the track in the bottom cover.
- Place the top cover over the unit and align the track over the heat sink.
- While holding the covers together at the rear of the unit, carefully push on the rear panel.
- Position the front panel so that the two slotted ears at the bottom of the panel align with the printed wiring boards.
- Carefully push on the front panel.

## 5-6 TEST EQUIPMENT REQUIRED

5-7 Table 5-1 lists the test equipment required to perform the various procedures described in this Section.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS (MIN)	USE	RECOMMENDED MODEL
Precision Voltmeter	Sensitivity: 1mV full scale (min.). Input impedance: 10 megohms (min.).	Measure dc voltages; calibration procedures	(HP) 3456
Variable Voltage Transformer	Range: 90-130 or 200-260 volts. Equipped with voltmeter accurate within 1 volt.	Vary ac input	----
AC Voltmeter	Accuracy: 2%. Sensitivity: 1 mV full scale deflection (min.).	Measure ac voltages and ripple	(HP) 3400
Oscilloscope	Sensitivity: 100 $\mu$ V/cm. Differential input.	Display transient response waveforms	(HP) 1800 plus 1801A and 1821A plug in's
Oscillator	Range: 5 Hz to 600 Hz. Accuracy: 2%. Output: 10 V rms.	Impedance checks	(HP) 200CD

**Table 5-1. Test Equipment Required (Continued).**

TYPE	REQUIRED CHARACTERISTICS (MIN)	USE	RECOMMENDED MODEL
DC Voltmeter	Accuracy:1%. Input resistance: 20,000 ohms/Volt (min.).	Measure dc voltages	(HP) 3456 or 3466
Repetitive Load Switch	Rate: 60-400 Hz, 2 $\mu$ sec rise and fall time.	Measure transient response	See Figure 5-7.
Resistive Loads	Values: See Paragraphs 5-16 and 5-47.	Power supply load resistors	----
Current Sampling Resistor	See R33 in Parts List (Section VI).	Measure current; calibrate meter	----
Resistor	1 K $\Omega$ $\pm$ 1%, 10 Watt.	Measure impedance	----
Capacitor	500 $\mu$ F, 50 W Vdc.	Measure impedance	----

## 5-8 PERFORMANCE TEST

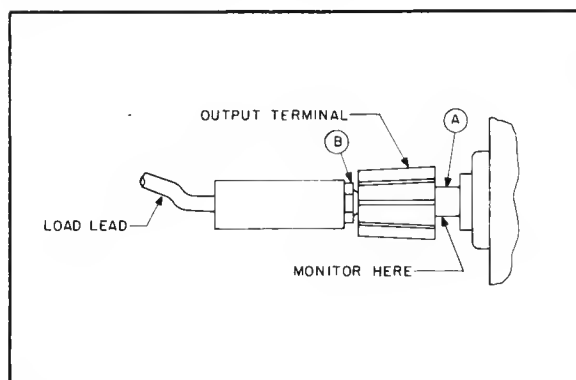
5-9 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated either to check the operation of the instrument after repairs or for periodic maintenance tests. The tests are performed using normal single phase input power source. if the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (Paragraph 5-57).

### 5-10 Constant Voltage Tests

5-11 The measuring device must be connected as close to the output terminals as possible when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance several orders of magnitude greater than the supply impedance, thus invalidating the measurement.

5-12 The monitoring device should be connected as shown in Figure 5-1. Note that the monitoring leads are connected at A, not B, as shown in Figure 5-1. Failure

to connect the measuring device at A will result in a measurement that includes the resistance of the leads between the output terminals and the point of connection. When measuring the constant voltage performance specifications, the current controls should be set well above the maximum output current which the supply will draw, since the onset of constant current action will cause a drop in output voltage, increased ripple, and other performance changes not properly ascribed to the constant voltage operation of the supply.



**Figure 5-1. Front Panel Terminal Connections.**



5-13      **Rated Output and Meter Accuracy.**

5-14      **Voltage.** To check the output voltage, proceed as follows:

- a. Connect load resistor ( $R_L$ ), indicated in Figure 5-2, across the output terminals of supply.
- b. Connect voltmeter across (+) and (-) terminals of supply observing correct polarity.
- c. Set METER SELECTION switch to VOLTS and turn on supply.
- d. Adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.
- e. Voltmeter should indicate maximum rated output voltage within  $\pm 4\%$ .

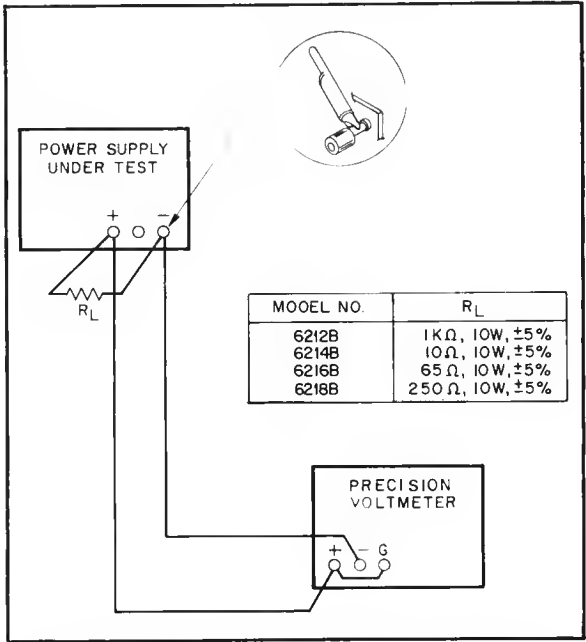


Figure 5-2. CV Load Regulation, Test Setup.

5-15      **Load Regulation.**

**Definition:** The change  $E_{OUT}$  in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-16      To check the constant voltage load regulation, proceed as follows:

- a. Connect test setup as shown in Figure 5-3.
- b. Set METER SELECTION switch to mA position.

- c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates maximum rated output current.
- d. Read and record voltage indicated on voltmeter.
- e. Disconnect load resistor.
- f. Reading on voltmeter should not vary from reading recorded in step d by more than 8mVdc.

5-17      **Line Regulation.**

**Definition:** The change,  $E_{OUT}$ , in the static value of dc output voltage resulting from a change in ac input voltage over the specified range from low line ( $-10\%$ ) to high line ( $+10\%$ ), or from high line to low line.

5-18      To test the line regulation, proceed as follows:

- a. Connect variable auto transformer between input power source and power supply power input.
- b. Connect test setup shown in Figure 5-2.
- c. Adjust variable auto transformer for low line ac input.
- d. Set METER SELECTION switch to VOLTS position.
- e. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.
- f. Read and record voltage indicated on voltmeter.
- g. Adjust variable auto transformer for high VAC input.
- h. Reading on voltmeter should not vary from reading recorded in step f by more than 4 mVdc.

5-19      **Ripple and Noise.**

**Definition:** The residual AC voltage which is superimposed on the DC output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS or (preferably) peak-to-peak value.

Ripple and noise measurement can be made at any input AC line voltage combined with any DC output voltage and load current within rating.

5-20      The amount of ripple and noise that is present on the power supply output is measured either in terms of the RMS or (preferably) peak-to-peak value. The peak-to-peak measurement is particularly important for applications where noise spikes could be detrimental to a sensitive load, such as logic circuitry. The RMS measurement is not an ideal representation of the noise, since fairly high output noise spikes of short duration could be

present in the ripple and not appreciably increase the RMS value.

5-21 The technique used to measure high frequency noise or "spikes" on the output of a power supply is more critical than the low frequency ripple and noise measurement technique; therefore the former is discussed separately in Paragraph 5-29.

**5-22 Ripple and Noise Measurement.** Figure 5-3 shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential  $E_G$  between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60 Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting noise signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply, and can completely invalidate the measurement.

5-23 The same ground current and pickup problems can exist if an RMS voltmeter is substituted in place of the oscilloscope in Figure 5-3. However, the oscilloscope display, unlike the true RMS meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120 Hz) or 16, 7 milliseconds (1/60 Hz). Since the fundamental ripple frequency present on the output of an HP supply is 120 Hz (due to full-wave rectification), an oscilloscope display showing a 120 Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60 Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measure ripple.

5-24 Figure 5-3 shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply. Note that to ensure that no potential difference exists between the supply and the oscilloscope it is recommended that whenever possible they both be plugged into the same ac power buss. If the grounds must be at earth ground potential.

5-25 Either a twisted pair or (preferably) a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be

taken that one of the two wires is connected to the grounded input terminal of the oscilloscope. When using shielded two-wire, it is essential for the shield to be connected to ground at one end only so that no ground current will flow through this shield, thus inducing a noise signal in the shielded leads.

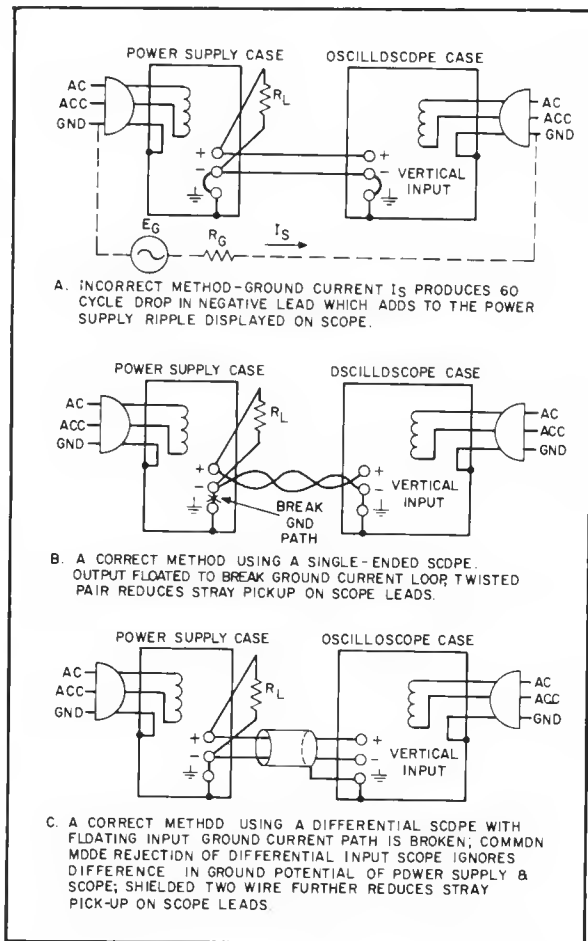


Figure 5-3. Ripple and Noise, Test Setup

5-26 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (-) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-27 In most cases, the single-ended scope method of Figure 5-3 will be adequate to eliminate non-real components of ripple and noise so that a satisfactory measurement may be obtained. However, in more stubborn cases it may be necessary to use a differential scope with floating input as shown in Figure 5-3C. If desired, two single conductor shielded cables may be substituted in

place of the shielded two-wire cable with equal success. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal introduced because of the difference in the AC potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

**5-28** To check the ripple and noise output, proceed as follows:

- Connect the oscilloscope or RMS voltmeter as shown in Figures 5-3B or 5-3C.
- Adjust VOLTAGE control until front panel meter indicates the maximum rated output voltage.
- The observed ripple and noise should be less than 200  $\mu$ Vrms and 1 mV p-p.

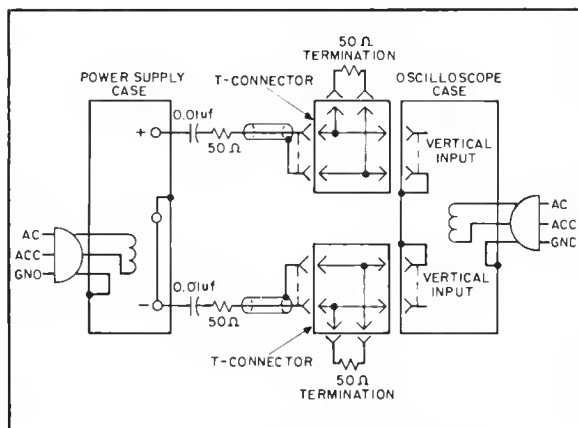
**5-29 Noise Spike Measurement.** When a high frequency spike measurement is being made, an instrument of sufficient bandwidth must be used; an oscilloscope with a bandwidth of 20 MHz or more is adequate. Measuring noise with an instrument that has insufficient bandwidth may conceal high frequency spikes detrimental to the load.

**5-30** The test setups illustrated in Figures 5-3A and 5-3B are generally not acceptable for measuring spikes; a differential oscilloscope is necessary. Furthermore, the measurement concept of Figure 5-3C must be modified if accurate spike measurement is to be achieved:

- As shown in Figure 5-4, two coax cables, must be substituted for the shielded two-wire cable.
- Impedance matching resistors must be included to eliminate standing waves and cable ringing, and the capacitors must be connected to block the DC current path.
- The length of the test leads outside the coax is critical and must be kept as short as possible; the blocking capacitor and the impedance matching resistor should be connected directly from the inner conductor of the cable to the power supply terminals.
- Notice that the shields of the power supply

end of the two coax cables are not connected to the power supply ground, since such a connection would give rise to a ground current path through the coax shield, resulting in an erroneous measurement.

- The measured noise spike values must be doubled since the impedance matching resistors constitute a 2-to-1 attenuator.
- The noise spikes observed on the oscilloscope should be less than 0.5 mV p-p.



**Figure 5-4. CV Noise Spike Test Setup**

**5-31** The circuit of Figure 5-4 can also be used for the normal measurement of low frequency ripple and noise; simply remove the four terminating resistors and the blocking capacitors and substitute a higher gain vertical plug-in in place of the wideband plug-in required for spike measurements. Notice that with these changes, Figure 5-4 becomes a two-cable version of Figure 5-3C.

## **5-32 Transient Recover Time.**

**Definition:** The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current – where: "Y" is specified separately for each model but is generally of the same order as the load regulation specification. The nominal output voltage is defined as the DC level half way between the static output voltage before and after the imposed load change, and "Z" is the specified load current change, normally equal to the full load current rating of the supply.

**5-33** Transient recovery time may be measured at any input line voltage combined with any output voltage and load current within rating.

**5-34** Reasonable care must be taken in switching the load resistance on and off. A hand-operated switch in-series with the load is not adequate, since the resulting

one-shot displays are difficult to observe on most oscilloscopes, and the arc energy occurring during switching action completely masks the display with a noise burst. Transistor load switching devices are expensive if reasonably rapid load current changes are to be achieved.

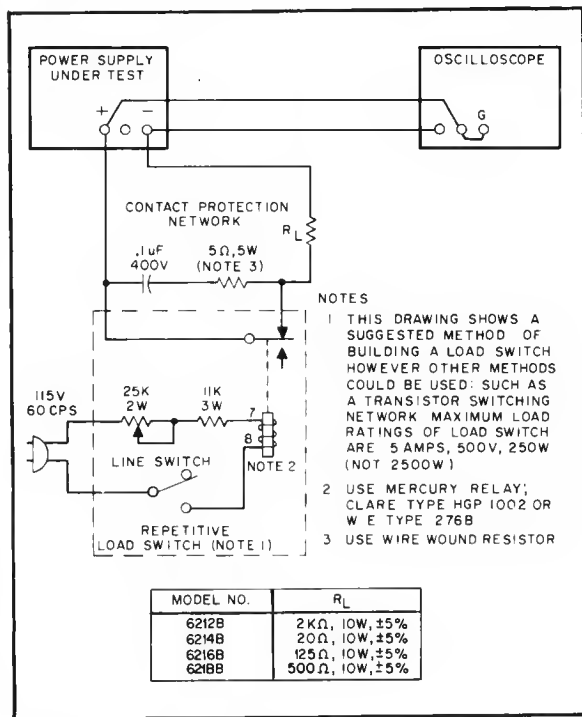


Figure 5-5. Transient Recovery Time, Test Setup

5-35 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-5 should be used for loading and unloading the supply. When the load switch is connected to a 60 Hz AC input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25 k control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display.

5-36 The maximum load ratings listed in Figure 5-5 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

5-37 To check the transient recovery time, proceed as follows:

- Connect test setup shown in Figure 5-5.
- Set METER SELECTION switch to mA.

- Turn on supply and adjust voltage controls until front panel meter indicates exactly the maximum rated output current.
- Close the line switch on the repetitive load switch setup.
- Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.
- Set the vertical input of the oscilloscope for ac coupling so that small dc level changes in the output voltage of the power supply will not cause the display to shift.
- Adjust the vertical centering on the scope so that the tail ends of the no load and full load waveforms are symetrically displaced about the horizontal center line of the oscilloscope. This center line now represents the nominal output voltage define in the specification.
- Adjust the horizontal positioning control so that the trace starts at a point coincident with a major graticule division. This point is then representative of time zero.
- Increase the sweep rate so that a single transient spike can be examined in detail.
- Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.
- Starting from the major graticule division representative of time zero, count to the right 50 μsec and vertically 15 mV. Recovery should be within these tolerances as illustrated in Figure 5-6.

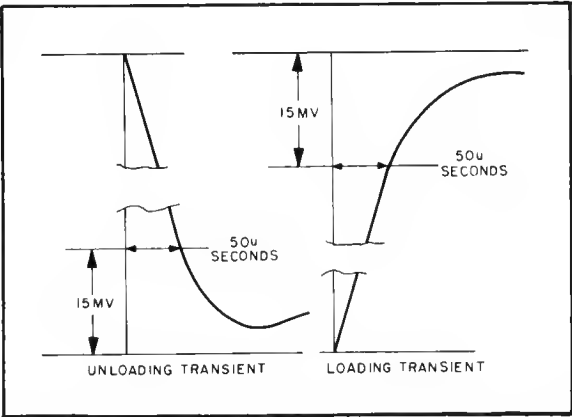


Figure 5-6. Transient Recovery Time, Waveforms.

### 5-38 Output Stability

**Definition:** The change in output voltage for the first eight hours following a 30 minute warm-up period. Dur-

ing the interval of measurement all parameters, such as load resistance, ambient temperature, and input line voltage are held constant.

5-39 This measurement is made by monitoring the output of the power supply on a differential voltmeter or digital voltmeter over the stated measurement interval; strip chart recorder can be used to provide a permanent record. A thermometer should be placed near the supply to verify that the ambient temperature remains constant during the period of measurement. The supply should be put in a location immune from stray air currents (open doors or windows, air conditioning vents); if possible, the supply should be placed in an over which is held at a constant temperature. Care must be taken that the measuring instrument has a stability over the eight hour interval which is at least an order of magnitude better than the stability specification of the power supply being measured. Typically, a supply may drift less over the eight hour measurement interval than during the 1/2 hour warm-up period.

5-40 To check the output stability, proceed as follows:

- a. Connect the load resistance and differential voltmeter as illustrated in Figure 5-2.
- b. Adjust front panel VOLTAGE controls until the differential voltmeter indicates the following:

6212B	100 V
6214B	10 V
6216B	25 V
6218B	50 V

- c. Allow 30 minutes warm-up then record the differential voltmeter
- d. After 8 hours, differential voltmeter should change from indication recorded in step c by less then the following:

6212B	105 mV
6214B	15 mV
6216B	30 mV
6218B	55 mV

5-41 Constant Current Tests

5-42 For output current measurements, the current sampling resistor must be treated as a four terminal device. In the manner of a meter shunt, the load current is fed to the extremes of the wire leading to the resistor while the sampling terminals are located as close as possible to the resistance portion itself (see Figure 5-7). Generally, any current sampling resistor should be of the low noise, low temperature coefficient (less than 30

ppm/°C) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized. The latter, reduces resistance changes due to thermal fluctuations. It is recommended that for resistor  $R_S$  the user obtain a duplicate of the sampling resistance ( $R_{33}$ ) that is used in this unit for constant current checks. For these tests, then,  $R_L$  is the difference between full-load resistance and current sampling resistor  $R_S$ .

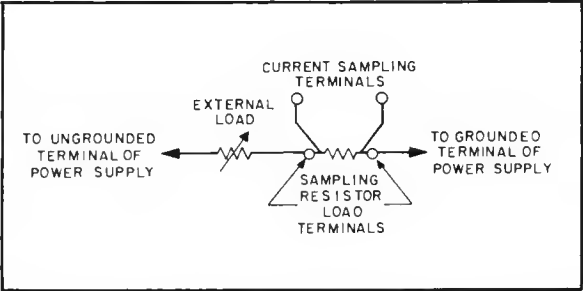


Figure 5-7. Current Sampling Resistor Connections.

5-43 Rated Output and Meter Accuracy

- a. Connect test setup shown in Figure 5-8.
- b. Set METER SELECTION switch to mA position.
- c. Turn CURRENT controls fully clockwise.
- d. Turn on supply and adjust VOLTAGE controls until front panel meter indicates maximum rated output current.
- e. Voltmeter should read:

6212B	1.00 V ± 0.04 V
6214B	1.00 V ± 0.03 V
6216B	1.15 V ± 0.035 V
6218B	1.20 V ± .036 V

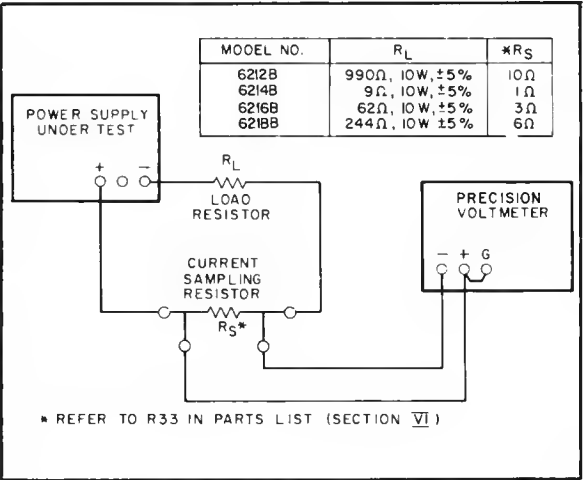


Figure 5-8. Constant Current, Test Setup

5-44 Load Regulation:

**Definition:** The change,  $I_{OUT}$  in the static value of the dc output current resulting from a change in load resistance from short circuit to a value which yields maximum rated output voltage.

5-45 To check the constant current load regulation, proceed as follows:

- a. Connect test setup shown in Figure 5-8.
- b. Turn VOLTAGE control(s) fully clockwise.
- c. Set METER switch to mA.
- d. Adjust CURRENT control until front panel meter reads exactly the maximum rated output current.
- e. Read and record voltage indicated on voltmeter.
- f. Short out load resistor ( $R_L$ ).
- g. Reading on differential voltmeter should not vary from reading recorded in step e by more than the following:

Model No.	6212B	6214B	6216B	6218B
Variation (mVdc)	5.0	.05	1.5	3

5-46 Line Regulation.

**Definition:** The change,  $I_{OUT}$  in the static value of dc output current resulting from a change in ac input voltage over the specified range from low line (usually 103 Volts) to high line (usually 127 Volts), or from high line to low line.

5-47 To check the line regulation proceed as follows:

- a. Utilize test setup shown in Figure 5-8.
- b. Connect variable auto transformer between input power source and power supply power input.
- c. Adjust auto transformer for 103 Vac input.
- d. Turn VOLTAGE control(s) fully clockwise.
- e. Set METER switch to mA.
- f. Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.
- g. Read and record voltage indicated on voltmeter.
- h. Adjust variable auto transformer for 127 Vac input.
- i. Reading on voltmeter should not vary from reading recorded in step g by more than the following:

Model No.	6212B	6214B	6216B	6218B
Variation (mVdc)	5.0	0.75	1.5	3.0

5-48 Ripple and Noise

**Definition:** The residual ac current which is superimposed on the dc output current of a regulated supply. Ripple and noise may be specified and measured in terms of its RMS or (preferably) peak-to-peak value.

5-49 Most of the instructions pertaining to the ground loop and pickup problems associated with constant voltage ripple and noise measurement also apply to the measurement of constant current ripple and noise. Figure 5-9 illustrates the most important precautions to be observed when measuring the ripple and noise of a constant current supply. The presence of a 120 cycle waveform on the oscilloscope is normally indicative of a correct measurement method. A waveshape having 60 Hz as its fundamental component is typically associated with an incorrect measurement setup.

5-50 **Ripple and Noise Measurement.** To check the peak-to-peak ripple and noise, proceed as follows:

- a. Connect the oscilloscope as shown in Figures 5-9B or 5-9C.
- b. Rotate the VOLTAGE control fully cw.
- c. Set METER switch to mA and turn on supply.
- d. Adjust CURRENT control until front panel meter reads exactly the maximum rated output current.
- e. The peak-to-peak ripple and noise indication should be less than:

6212B	6214B	6216B	6218B
5.0 mV	0.5 mV	1.5 mV	3.0 mV

5-51 TROUBLESHOOTING

5-52 Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument and not with an associated circuit. The performance test (Paragraph 5-8) enables this to be determined without having to remove the instrument from the cabinet.

NOTE

*The normal voltages shown on the schematic diagram at the rear of the manual are positioned adjacent of the applicable test point (identified by encircled numbers on the component location diagram and schematic diagram, Figures 7-1 and 7-2).*

5-54 Once the defective component has been located (by means of visual inspection or trouble analysis) replace it and reconduct the performance test. If a component is replaced, refer to the repair and replacement and adjustment and calibration paragraphs in this section.

## 5-55 Overall Troubleshooting Procedure

5-56 To locate the cause of trouble follow steps 1, 2, and 3 in sequence.

1. Check for obvious troubles such as open fuse, defective power cord, input power failure, or defective voltage or current meter. Next remove the top and bottom covers, as described in Paragraph 5-3, and inspect for open connections, charred components, etc. If the trouble source cannot be detected by visual inspection, proceed with step 2.
2. In almost all cases, the trouble can be caused by the dc bias or reference voltages; thus, it is a good practice to check voltages in Table 5-2 before proceeding with step 3.
3. Examine Table 5-3 to determine your symptoms, then check the probable cause.

5-57 **Regulating Loop Troubles.** If the voltages in Table 5-2 have been checked to eliminate the reference, bias and rectifier circuits as a source of trouble the malfunction is caused by the voltage regulating loop. If any component in a feedback loop is defective, measurements made anywhere in the loop may appear abnormal. Under these circumstances it is very difficult to separate cause from effect with the loop closed. As described in Tables 5-4 and 5-5, the loop is effectively opened by checking the conduction and cutoff capability of each stage as follows:

1. Shorting the emitter to collector of a transistor simulates saturation, or the full ON condition.
2. Shorting the emitter to base or opening the collector lead of a transistor cuts it off, and simulates an open circuit between emitter and collector.

5-58 For low or high output voltage perform the instructions in Tables 5-4, or 5-5, respectively. Although a logical first choice might be to start near the loop midpoint, and then perform successive subdividing test, it is more useful to trace the loop from the series regulator backwards a stage at a time, since loop failures occur more often at the higher power levels.

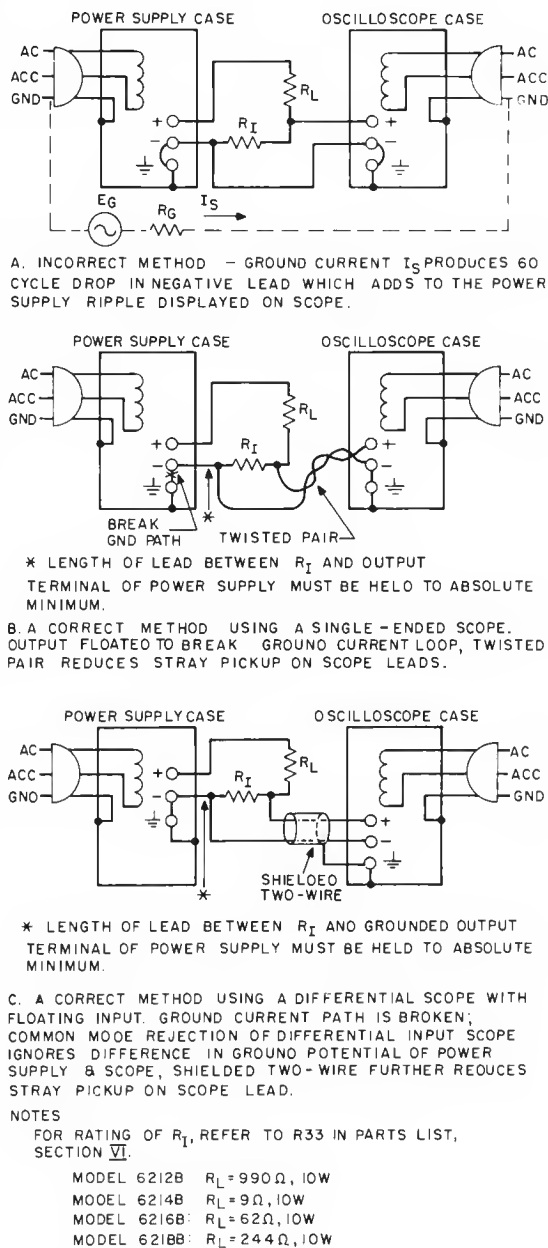


Figure 5-9. CC Ripple and Noise Test Setup

5-53 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the read review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, refer to the overall troubleshooting procedures in Paragraph 5-56 to locate the symptom and probable cause.

**Table 5-2. Reference, Bias, and Filtered DC Troubleshooting**

METER COMMON	METER POSITIVE	NORMAL VDC	NORMAL RIPPLE (P-P)	PROBABLE CAUSE
C5 (–)	C5 (+)	+40 ± 4.8 V	2 V	T1, C10, CR10, CR11, C5
+S	7	+11.5 ± 0.6 V	0.5 mV	VR4, VR5, VR6, Q11, R25
+S	8	+6.2 ± 0.3 V	0.2 mV	VR6, R25
9	+S	+6.2 ± 0.3 V	0.1 mV	VR3, VR8, Q9, R30
11	+S	+12.4 ± 0.6 V	4.5 mV	VR1, VR9, R30, R20(6212)
– OUT	6	150 ± 15.0 V (6212B) 19 ± 2.2V (6214B) 44 ± 4.5 V (6216B) 78 ± 7.8 V (6218B)	500 mV 500 mV 400 mV 500 mV	6212B CR15-CR18, C9, R32, T1, C11 6214B CR15-CR18, C9, R32, T1, C11 6216B CR15, CR16, C9, C11, C12, R32, T1 6218B CR15, CR16, C9, C11, C12, R32, T1

**Table 5-3. Overall Troubleshooting**

SYMPTOM	PROBABLE CAUSE
Low Output Or No Out- put Voltage	Ensure that the front panel meter is not defective, then refer to paragraph 5-58.
High Out- put Voltage	Ensure that the front panel meter is not defective, then refer to paragraph 5-58.
<p style="text-align: center;">————— C —————</p> <p>Never set the output voltage controls to zero volts when there is high or low output voltage; damage to the voltage controls could result.</p>	

SYMPTOM	PROBABLE CAUSE
Inability To Reach 0V ± 1 mV Output	a. Output voltage control R10 defective. b. Amplifier Q1, Q2 defective.
Oscillates	C3, R17 defective
Slow Drift	a. Measuring equipment b. Reference diode VR6 c. Q1 or Q2 d. Insufficient warm-up time (should be 30 minutes).



Table 5-3. Overall Troubleshooting (Continued)

SYMPTOM	PROBABLE CAUSE
High Ripple	<ul style="list-style-type: none"> <li>a. Check operating setup for ground loops.</li> <li>b. If output floating, connect 1 <math>\mu</math>f capacitor between output and ground.</li> <li>c. Check for excessive internal ripple; refer to (Table 5-2).</li> <li>d. Ensure that supply is not in constant current mode under loaded conditions.</li> <li>e. Check that the test point (15) is approx. -0.5 V. If voltage is between 0 and +3 V, supply is in constant current operation or constant current input amplifier is defective.</li> </ul>
Poor Transient Recovery Time	R17, C3 defective Recovery Time
Poor Line Regulation (Constant Voltage)	<ul style="list-style-type: none"> <li>a. Improper measuring technique; refer to paragraph 5-11.</li> <li>b. Check reference circuit voltages, (Table 5-2).</li> </ul>
Poor Load Regulation (Constant Voltage)	<ul style="list-style-type: none"> <li>a. Improper measuring technique; refer to paragraph 5-11.</li> <li>b. Check reference circuit voltage (Table 5-2).</li> </ul>
Poor load Regulation (Constant Voltage) (Cont'd)	<ul style="list-style-type: none"> <li>c. Ensure that supply is not in constant current operation under loaded conditions. To prevent this condition, ensure that output current does not exceed maximum rated output and that the current controls are fully clockwise.</li> </ul>

SYMPTOM	PROBABLE CAUSE
Poor Stability (Constant Current)	<ul style="list-style-type: none"> <li>a. Check -6.2 Vdc reference voltage (Table 5-2).</li> <li>b. noisy programming resistor R11.</li> <li>c. CR20, CR14, C14 leaky.</li> <li>d. Check R42, R43, and R33 for noise or drift.</li> <li>e. Stage Q12/Q13 defective.</li> </ul>
Poor Stability (Constant Voltage)	<ul style="list-style-type: none"> <li>a. Check +6.2 Vdc reference voltage (Table 5-2).</li> <li>b. Noisy programming resistor R10.</li> <li>c. CR1, CR2 leaky.</li> <li>d. Check R1, R12, and C1 for noise or drift.</li> <li>e. Stage Q1/Q2 defective.</li> </ul>
Poor Load Regulation (Constant Current)	<ul style="list-style-type: none"> <li>a. Improper measuring technique; refer to paragraph 5-43.</li> <li>b. Check reference circuit voltages (Table 5-2).</li> <li>c. C14 and CR14 leaky.</li> <li>d. Check clamp circuit Q3, CR3, CR4, and VR2.</li> <li>e. Ensure that supply is not crossing over into constant voltage operation. To prevent this condition, load the supply and turn the VOLTAGE control fully clockwise.</li> </ul>

Table 5-4. Low Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Turn the VOLTAGE control fully clockwise and disconnect the load		
2	To eliminate the constant current circuit as a cause of the malfunction, remove CR6 cathode or anode lead	a. Output increases b. Output remains low	a. CR6 or constant current amplifier defective b. Reconnect CR6 and proceed to Step 3
3	Check conduction of Q7 by shorting Q5 emitter to collector.	a. Output remains low b. Output increases	a. Q7, CR7 or associated parts defective. b. Remove jumper and proceed to Step 4.
4	Check conduction of Q5 by shorting Q4 emitter to collector	a. Output remains low b. Output increases	a. Q5, CR13, R19, R23 b. Remove jumper and proceed to Step 5.
5	Check conduction of Q4 by shorting Q1 emitter to collector	a. Output remains low b. Output increases	a. Stage Q4 defective b. Stage Q1/Q2 defective. Check R10, C1 for short and R12 for open.

Table 5-5. High Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Turn the VOLTAGE control to approximately mid-range and disconnect the load. If the output voltage should rise to an excessive value during the following procedures, the VOLTAGE control could be damaged if it is turned full CCW.		
2	Check turnoff of Q7 by disconnecting Q5 emitter lead	a. Output remains high b. Output decreases	a. Q7, CR7 or associated parts defective. b. Replace Q5 and proceed to Step 3.
3	Check turnoff of Q5 by removing Q4 collector lead	a. Output remains high b. Output decreases	a. Stage Q5 defective b. Replace Q4 collector lead and proceed to Step 4.

Table 5-5. High Output Voltage Troubleshooting (continued)

STEP	ACTION	RESPONSE	PROBABLE CAUSE
4	Check turnoff of Q4 by removing Q1 collector lead	a. Output remains high b. Output decreases	a. Stage Q4 defective b. Replace Q1 collector lead and proceed to Step 5.
5	Remove CR3 anode or cathode	a. Output decreases b. Output remains high	a. voltage clamp circuit is defective b. Reconnect CR3 and proceed to Step 6.
6	Connect a jumper between (–) out and test point (1)	a. Output remains high b. Output decreases	a. Stage Q1/Q2 defective b. Remove short and check R10 for open and R12 for short

Table 5-6. Selected Semiconductor Characteristics

REFERENCE DESIGNATOR	CHARACTERISTICS	HP PART NO.	SUGGESTED REPLACEMENT
Q7	Power NPN Silicon $h_{fe} = 35$ min. @ $I_C = 4A$ $V_{CE} = 4V$	1854-0225	2N3055 R.C.A.

## 5-59 REPAIR AND REPLACEMENT

5-60 Before servicing a printed wiring board, refer to Figure 5-10. Section VI of this manual contains a tabular list of the instrument's replaceable parts. Before replacing a semiconductor device, refer to Table 5-6 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-6, the standard manufacturers' part number listed in Section VI is applicable.

## 5-61 ADJUSTMENT AND CALIBRATION

5-62 Adjustment and calibration may be required after performance testing, troubleshooting, or repair and replacement. Perform only those adjustments that affect the operation of the faulty circuit and no others.

## 5-63 Meter Mechanical Zero

5-64 Proceed as follows to zero meter:

- Turn off instrument (after it has reached normal operating temperature) and allow 30 seconds for all capacitors to discharge.
- Insert sharp pointed object (pen point or

awl) into the small hole at top of round black plastic disc located directly below meter face.

- Rotate plastic disc clockwise (cw) until meter reads zero, then rotate ccw slightly in order to free adjustment screw from meter suspension. If point moves, repeat steps b and c.

## 5-65 Meter Calibration

5-66 To calibrate the ammeter, proceed as follows:

- Connect test setup shown on figure 5-8.
- Set CURRENT control fully clockwise.
- Set METER SELECTION switch to mA.
- Turn on supply and adjust VOLTAGE controls so that differential voltmeter indicates exactly as follows:

6212B	1.00 V	6216B	1.15 V
6214B	1.00 V	6218B	1.20 V

- Adjust R52 until front panel ammeter indicates: 6212B, 100 mA; 6214B, 1 A; 6216B, 400 mA; 6218 B, 200 mA.

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

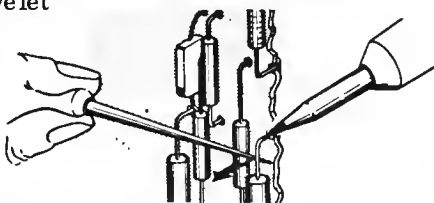
Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

**WARNING:** If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet

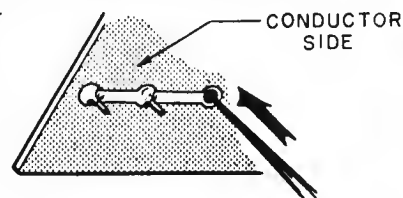
in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet,



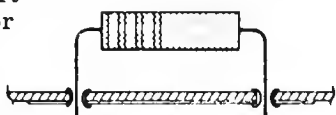
apply heat to conductor side of board.

2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole.

If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.

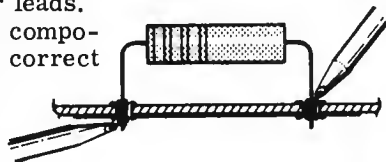


3. Bend clean tinned lead on new part and carefully insert through eyelets or holes in board.



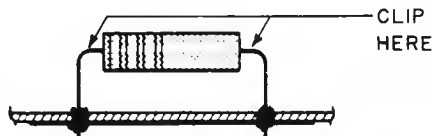
4. Hold part against board (avoid overheating) and solder leads.

Apply heat to component leads on correct side of board as explained in step 1.

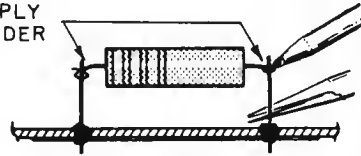


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-10. Servicing Printed Wiring Boards.

# Section VI

## REPLACEABLE PARTS

### 6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

- Reference Designators. Refer to Table 6-1.
- Description. Refer to Table 6-2 for abbreviations.
- Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.
- Manufacturer's Part Number of Type.
- Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.
- Hewlett-Packard Part Number.
- Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.
- Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

### 6-3 ORDERING INFORMATION

6-4 To order replacement parts, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

**Table 6-1. Reference Designators.**

<b>A</b> = assembly	<b>E</b> = miscellaneous
<b>B</b> = blower (fan)	electronic part
<b>C</b> = capacitor	<b>F</b> = fuse
<b>CB</b> = circuit breaker	<b>J</b> = jack, jumper
<b>CR</b> = diode	<b>K</b> = relay
<b>DS</b> = device, signaling (lamp)	<b>L</b> = inductor
	<b>M</b> = meter

**Table 6-1. Reference Designators (Continued)**

<b>P</b> = plug	<b>V</b> = vacuum tube,
<b>Q</b> = transistor	neon bulb,
<b>R</b> = resistor	photocell, etc.
<b>S</b> = switch	<b>VR</b> = zener diode
<b>T</b> = transformer	<b>X</b> = socket
<b>TB</b> = terminal block	<b>Z</b> = integrated circuit or network
<b>TS</b> = thermal switch	

**Table 6-2. Description Abbreviations**

<b>A</b> = ampere	mod. = modular or modified
<b>ac</b> = alternating current	mtg = mounting
<b>assy.</b> = assembly	<b>n</b> = nano = $10^{-9}$
<b>bd</b> = board	<b>NC</b> = normally closed
<b>bkt</b> = bracket	<b>NO</b> = normally open
<b>°C</b> = degree Centigrade	<b>NP</b> = nickel-plated
<b>cd</b> = card	<b>Ω</b> = ohm
<b>coef</b> = coefficient	<b>obd</b> = order by description
<b>comp</b> = composition	<b>OD</b> = outside diameter
<b>CRT</b> = cathode-ray tube	<b>p</b> = pico = $10^{-12}$
<b>CT</b> = center-tapped	<b>P.C.</b> = printed circuit
<b>dc</b> = direct current	<b>pot.</b> = potentiometer
<b>DPDT</b> = double pole, double throw	<b>p-p</b> = peak-to-peak
<b>elect</b> = electrolytic	<b>ppm</b> = parts per million
<b>encap</b> = encapsulated	<b>pvr</b> = peak reverse voltage
<b>F</b> = farad	<b>rect</b> = rectifier
<b>°F</b> = degree Fahrenheit	<b>rms</b> = root mean square
<b>fxd</b> = fixed	<b>Si</b> = silicon
<b>Ge</b> = germanium	<b>SPDT</b> = single pole, single throw
<b>H</b> = Henry	<b>SS</b> = small signal
<b>Hz</b> = Hertz	<b>T</b> = slow-blow
<b>IC</b> = integrated circuit	<b>tan.</b> = tantulum
<b>ID</b> = inside diameter	<b>Ti</b> = titanium
<b>incnd</b> = incandescent	<b>V</b> = volt
<b>k</b> = kilo = $10^3$	<b>var</b> = variable
<b>m</b> = milli = $10^{-3}$	<b>ww</b> = wirewound
<b>M</b> = mega = $10^6$	<b>W</b> = Watt
<b>μ</b> = micro = $10^{-6}$	
<b>met.</b> = metal	
<b>mfr</b> = manufacturer	

Table 6-3. Manufacturer's Federal Supply Codes

01121	Allen-Bradley Co.	Milwaukee, WI
03508	General Electric Co. Semiconductor Products Department	Auburn, NY
04713	Motorola Semiconductor Products, Inc.	Phoenix, AZ
06001	Mepco/Electra Corp.	Columbus, SC
14140	Edison Elek Division McGraw-Edison	Manchester, NH
19701	Mepco/Electra Corp.	Mineral Wells, TX
24546	Corning Glass Works	Bradford, PA
28480	Hewlett-Packard Co.	Palo Alto, CA
56289	Sprague Electric Co.	North Adams, MA

Table 6-4. 621B/14B/16B/18B/ Parts List

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
C1			A1 MAIN BOARD		
C2	0180-1835	1	NOT ASSIGNED		
C3			fxd elect 68uF $\pm 20\%$ 15V	56289	150D686X0015R2
6212B	0160-0157	1	fxd film 4700pF $\pm 10\%$ 200V	28480	
6214B	0160-0159	1	fxd film 6800pF $\pm 10\%$ 200V	28480	
6216B	0160-0159	1	fxd film 6800pF $\pm 10\%$ 200V	28480	
6218B	0160-0157	2	fxd film 4700pF $\pm 10\%$ 200V	28480	
C4					
6212B	0160-2061	1	fxd cer 100pF $\pm 10\%$ 1kVdc	28480	
6214B	0160-0157	1	fxd film 4700pF $\pm 10\%$ 200V	28480	
6216B	0160-0157	1	fxd film 4700pF $\pm 10\%$ 200V	28480	
6218B	0160-0157		fxd film 4700pF $\pm 10\%$ 200V	28480	
C5					
6212B	0180-1852	1	fxd elect 100uF $\pm 75-10\%$ 50V	28480	
6214B	0180-1884	1	fxd elect 200uF $\pm 100-10\%$ 65V	28480	
6216B	0180-1852	1	fxd elect 100uF $\pm 75-10\%$ 50V	28480	
6218B	0180-1852	1	fxd elect 100uF $\pm 75-10\%$ 50V	28480	
C6	0160-0161	1			
C7					
6212B			NOT ASSIGNED		
6214B	0160-3070	1	fxd mica 100pF $\pm 5\%$ 300V	28480	
6216B	0160-3070	1	fxd mica 100pF $\pm 5\%$ 300V	28480	
6218B	0160-3070	1	fxd mica 100pF $\pm 5\%$ 300V	28480	
C8			NOT USED		
C9					
6212B	0180-1885	1	fxd elect 200uF $\pm 75-10\%$ 250V	28480	
6214B	0180-1916	1	fxd elect 2000uF $\pm 100-10\%$ 28V	28480	
6216B	0180-1888	1	fxd elect 490uF $\pm 75-10\%$ 85V	06001	87F655BA8
6218B	0180-1887	1	fxd elect 400uF $\pm 65-10\%$ 150V	28480	
C10					
6212B	0150-0024	2	fxd cer .02uF $\pm 80-20\%$ 600V	28480	
6214B	0150-0024	2	fxd cer .02uF $\pm 80-20\%$ 600V	28480	
6216B	0150-0024	3	fxd cer .02uF $\pm 80-20\%$ 600V	28480	
6218B	0150-0024	2	fxd cer .02uF $\pm 80-20\%$ 600V	28480	
C11	0150-0024				

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
C12					
6212B			NOT ASSIGNED		
6214B			NOT ASSIGNED		
6216B	0150-0024		fxd cer .02uF +80-20% 600V	28480	
6218B			NOT ASSIGNED		
C13			NOT USED		
C14					
6212B	0180-1851	1	fxd elect 80uF +75-10% 300V	06001	87F742BA4
6214B	0180-2258	1	fxd elect 80uF +50-10% 65V	28480	
6216B	0180-2258	1	fxd elect 80uF +50-10% 65V	28480	
6218B	0180-2258	1	fxd elect 80uF +50-10% 65V	28480	
C15					
6212B			NOT ASSIGNED		
6214B	0180-2141	1	fxd elect 3.3uF $\pm$ 10% 50V	56289	150D335X9050B2
6216B	0180-2141	1	fxd elect 3.3uF $\pm$ 10% 50V	56289	150D335X9050B2
6218B	0180-1836		fxd elect 5uF +75-10% 65V	28480	
C16-30			NOT USED		
C31					
6212B	0160-0174	1	fxd cer 0.47uF +80-20% 25V		
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
CR1,2	1901-0033	4	gen prp 200mA 180V	28480	
CR3	1901-0461	3	gen prp 10V 200mA	28480	
CR4	1901-0033		gen prp 200mA 180V	28480	
CR5,6	1901-0461				
CR7					
6212B	1901-0328	6	pwr rect 1A 400V	03508	A14D
6214B	1901-0327	8	pwr rect 1A 200V	03508	A14B
6216B	1901-0327	6	pwr rect 1A 200V	03508	A14B
6218B	1901-0327	8	pwr rect 1A 200V	03508	A14B
CR8,9			NOT USED		
CR10,11					
6212B	1901-0327	2	pwr rect 1A 200V	03508	A14B
6214B	1901-0327		pwr rect 1A 200V	03508	A14B
6216B	1901-0327		pwr rect 1A 200V	03508	A14B
6218B	1901-0327		pwr rect 1A 200V	03508	A14B
CR12			NOT USED		
CR13	1901-0460	1	stabistor 150mA 30V	28480	
CR14-16	1901-0327		pwr rect 1A 200V	03503	A14B
CR17,18					
6212B	1901-0327		pwr rect 1A 200V	03508	A14B
6214B	1901-0327		pwr rect 1A 200V	03508	A14B
6216B			NOT ASSIGNED		
6218B	1901-0327		pwr rect 1A 200V	03508	A14B
CR19			NOT USED		
CR20	1901-0033		gen prp 200mA 180V	28480	
Q1,2					
6212B	1854-0823	5	NPN Si	28480	
6214B	1854-0823	4	NPN Si	28480	
6216B	1854-0823	4	NPN Si	28480	
6218B	1854-0823	4	NPN Si	28480	
Q3,4					
6212B	1853-0099	2	PNP Si	28480	
6214B	1853-0099	3	PNP Si	28480	
6216B	1853-0099	3	PNP Si	28480	
6218B	1853-0099	3	PNP Si	28480	
Q5					
6212B	1854-0823		NPN Si	28480	
6214B	1853-0041	1	PNP Si	28480	
6216B	1853-0041	1	PNP Si	28480	
6218B	1853-0041	1	PNP Si	28480	

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
Q6			NOT USED		
Q7			NOT ASSIGNED		
Q8			NOT USED		
Q9	1854-0087	1	NPN Si	28480	
Q10			NOT USED		
Q11					
6212B	1853-0041	1	PNP Si	28480	
6214B	1853-0099		PNP Si	28480	
6216B	1853-0099		PNP Si	28480	
6218B	1853-0099		PNP Si	28480	
Q12, 13	1854-0823		NPN Si		
R1					
6212B	0812-0050	1	fxd ww 3k 5% 5W	28480	
6214B	0813-0001	1	fxd ww 1k 5% 3W	28480	
6216B	0813-0001	2	fxd ww 1k 5% 3W	28480	
6218B	0813-0001	1	fxd ww 1k 5% 3W	28480	
R2					
6212B	0757-0480	1	fxd film 432k 1% 1/8W	19701	MF4C1/8-T0-4323F
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
R3-5			NOT USED		
R6					
6212B	0757-0437	1	fxd film 4.75k 1% 1/8W	24546	C4-1/8-T0-4751-F
6214B	0757-0427	2	fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
6216B	0757-0427	2	fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
6218B	0757-0427	2	fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
R7			NOT USED		
R8			NOT ASSIGNED		
R9			NOT USED		
R10			NOT ASSIGNED		
R11			NOT ASSIGNED		
R12					
6212B	0811-2573	1	fxd ww 1.124k 0.1% 1/8W	14140	1274-1/16-C-1124R
6214B	0811-1808	1	fxd ww 2.6k 5% 3W	28480	
6216B	0813-0001		fxd ww 1k 5% 3W	28480	
6218B	0811-2879	1	fxd ww 4.64k 0.1% 1/5W	14140	1350-1/16-E-4641B
R13			NOT USED		
R14			NOT ASSIGNED		
R15, 16			NOT USED		
R17					
6212B	0686-1235	1	fxd comp 12k 5% 1/2W	01121	EB1235
6214B	0686-6225	2	fxd comp 6.2k 5% 1/2W	01121	EB6225
6216B	0686-7525	1	fxd comp 7.5k 5% 1/2W	01121	EB7525
6218B	0686-6825	1	fxd comp 6.8k 5% 1/2W	01121	EB6825
R18					
6212B	0686-2035	1	fxd comp 20k 5% 1/2W	01121	EB2035
6214B	0686-6225		fxd comp 6.2k 5% 1/2W	01121	EB6225
6216B	0686-6225	1	fxd comp 6.2k 5% 1/2W	01121	EB6225
6218B	0686-6225	1	fxd comp 6.2k 5% 1/2W	01121	EB6225
R19					
6212B	0686-1035	2	fxd comp 10k 5% 1/2W	01121	WB1035
6214B	0686-1025	2	fxd comp 1k 5% 1/2W	01121	EB1025
6216B	0686-1025	3	fxd comp 1k 5% 1/2W	01121	EB1025
6218B	0686-1025	3	fxd comp 1k 5% 1/2W	01121	EB1025
R20					
6212B	0813-0010	1	fxd ww 820 5% 3W	28480	
6214B	0813-0010	1	fxd ww 820 5% 3W	28480	
6216B	0764-0025	1	fxd met 2k 5% 2W	28480	
6218B	0764-0025	1	fxd met 2k 5% 2W	28480	



Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R21					
6212B	0686-2215	1	fxd comp 220 5% 1/2W	01121	CB2215
6214B	0686-2415	1	fxd comp 240 5% 1/2W	01121	CB2415
6216B	0686-2415	1	fxd comp 240 5% 1/2W	01121	CB2415
6218B	0686-2215	1	fxd comp 220 5% 1/2W	01121	CB2215
R22					
6212B	0686-5635	1	fxd comp 56k 5% 1/2W	01121	CB5635
6214B	0686-3035	1	fxd comp 30k 5% 1/2W	01121	CB3035
6216B	0686-3035	1	fxd comp 30k 5% 1/2W	01121	CB3035
6218B	0686-3035	1	fxd comp 30k 5% 1/2W	01121	CB3035
R23					
6212B	0683-1035		fxd comp 10k 5% 1/4W	01121	CB1035
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
R24	0689-3625	1	fxd comp 3.6k 5% 1W	01121	GB3625
R25					
6212B	0686-4315	1	fxd comp 430 5% 1/2W	01121	CB4315
6214B	0686-4715	1	fxd comp 470 5% 1/2W	01121	CB4715
6216B	0686-5115	1	fxd comp 510 5% 1/2W	01121	CB5115
6218B	0686-4315	1	fxd comp 430 5% 1/2W	01121	CB4315
R26					
6212B	0686-1515	1	fxd comp 150 5% 1/2W	01121	CB1515
6214B	0686-2015	1	fxd comp 200 5% 1/2W	01121	CB2015
6216B	0686-2015	1	fxd comp 200 5% 1/2W	01121	CB2015
6218B	0686-2015	1	fxd comp 200 5% 1/2W	01121	CB2015
R27			NOT USED		
R28					
6212B	0686-2025	1	fxd comp 2k 5% 1/2W	01121	CB2025
6214B	0686-8215	2	fxd comp 820 5% 1/2W	01121	CB8215
6216B	0686-8215	1	fxd comp 820 5% 1/2W	01121	CB8215
6218B	0686-8215	1	fxd comp 820 5% 1/2W	01121	CB8215
R29			NOT USED		
R30					
6212B	0686-6815	1	fxd comp 680 5% 1/2W	01121	CB6815
6214B	0686-3915	1	fxd comp 390 5% 1/2W	01121	CB3915
6216B	0686-1825	1	fxd comp 1.8k 5% 1/2W	01121	CB1825
6218B	0686-1825	1	fxd comp 1.8k 5% 1/2W	01121	CB1825
R31					
6212B	0686-1025	2	fxd comp 1k 5% 1/2W	01121	CB1025
6214B	0686-8215		fxd comp 820 5% 1/2W	01121	CB8215
6216B	0686-1025		fxd comp 1k 5% 1/2W	01121	CB1025
6218B	0686-1025		fxd comp 1k 5% 1/2W	01121	CB1025
R32					
6212B	0764-0045	1	fxd met 22k 5% 2W	28480	
6214B	0811-1799	1	fxd ww 390 5% 3W	28480	
6216B	0698-3642	1	fxd met 3k 5% 2W	27167	FP42-2-100-5001-J
6218B	0811-1814	1	fxd ww 6.5k 5% 3W	28480	
R33					
6212B	0811-1718	1	fxd ww 10 5% 3W	28480	
6214B	0811-1340	1	fxd ww 1 5% 5W	28480	
6216B	0811-1986	1	fxd ww 3 0.5% 3W	28480	
6218B	0811-2499	1	fxd ww 6 0.5% 3W	28480	
R34, 35			NOT USED		
R36					
6212B	0686-1015	1	fxd comp 100 5% 1/2W	01121	CB1015
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
R37, 38			NOT USED		

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R39					
6212B	0689-3335	1	fxd comp 33k 5% 1W	01121	GB3335
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
R40, 41			NOT USED		
R42					
6212B	0698-3269	1	fxd film 23k 1% 1/8W	24546	C4-1/8-T0-2302-F
6214B	0698-3269	1	fxd film 23k 1% 1/8W	24546	C4-1/8-T0-2302-F
6216B	0698-5091	1	fxd film 45k 1% 1/8W	24546	C4-1/8-T0-4502-F
6218B	0698-5091	1	fxd film 45k 1% 1/8W	24546	C4-1/8-T0-4502-F
R43					
6212B	0757-0934	1	fxd film 2.7k 2% 1/8W	24546	C4-1/8-T0-2701-G
6214B	0757-0427		fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
6216B	0757-0427		fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
6218B	0757-0427		fxd film 1.5k 1% 1/8W	24546	C4-1/8-T0-1501-F
R44-47			NOT USED		
R48		1			
6212B	0757-0280	2	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
6214B	0757-0280	2	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
6216B	0757-0280	1	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
6218B	0757-0280	1	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
R49, 50					
R51					
6212B	0757-0274	1	fxd film 1.21k 1% 1/8W	24546	C4-1/8-T0-1211-F
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
R52					
6212B	2100-0328	1	trmr ww 1-turn 500 10%	28480	
6214B	2100-0439	1	trmr ww 1-turn 250 20%	28480	
6216B	2100-0439	1	trmr ww 1-turn 250 20%	28480	
6218B	2100-0439	1	trmr ww 1-turn 250 20%	28480	
R53-55			NOT ASSIGNED		
R56			NOT USED		
R57			NOT ASSIGNED		
R58-60			NOT USED		
R61	0686-1025		fxd comp 1k 5% 1/2W	01121	EB1025
VR1	1902-3185	1	zener 12.4V 5%	28480	
VR2	1902-3070	3	zener 4.22V 5%	28480	
VR3	1902-0761	2	zener 6.2V 5%	04713	1N821
VR4	1902-0064	1	zener 7.5V 5%	28480	
VR5	1902-3070		zener 4.22V 5%	28480	
VR6	1902-0761		zener 6.2V 5%	04713	1N821
VR7	1902-0049	1	zener 6.19V 5%	28480	
VR8	1902-3070		zener 4.22V 5%	28480	
VR9					
6212B	1902-3002	1	zener 2.37 5%	28480	
6214B			NOT ASSIGNED		
6216B			NOT ASSIGNED		
6218B			NOT ASSIGNED		
Z1	1810-0031	1	resistance network	28480	
			14-dip multiple value		
C1			A2 FRONT PANEL BOARD		
6212B	0180-1841	1	fxd elect 5uF +50-10% 150V	56289	40D5051F150DC4
6214B	0180-0301	1	fxd elect 5uF +75-10% 50V	56289	30D505G050BB2
6216B	0180-1836	1	fxd elect 5uF +75-10% 65V	28480	
6218B	0180-1836	2	fxd elect 5uF +75-10% 65V	28480	
DS1	1450-0510	1	LED	28480	

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R1-7			NOT ASSIGNED		
R8					
6212B	0686-7505	1	fxd comp 75 5% 1/2W	01121	EB7505
6214B	0686-2405	1	fxd comp 24 5% 1/2W	01121	EB2405
6216B	0686-2405	1	fxd comp 24 5% 1/2W	01121	EB2405
6218B	0686-2405	1	fxd comp 24 5% 1/2W	01121	EB2405
R9			NOT ASSIGNED		
R10					
6212B	2100-0998	1	var dual ww 22k 10%	28480	
6214B	2100-2526	2	var dual ww 5k 5%	28480	
6216B	2100-2526	1	var dual ww 5k 5%	28480	
6218B	2100-2527	2	var dual ww 10k 5%	28480	
R11					
6212B	2100-2526	1	var dual ww 5k 5%	28480	
6214B	2100-2526		var dual ww 5% 5%	28480	
6216B	2100-2527	1	var dual ww 10k 5%	28480	
6218B	2100-2527		var dual ww 10k 5%	28480	
R12, 13			NOT ASSIGNED		
R14					
6212B	0698-5479	1	fxd comp 8.2 5% 1/2W	01121	EB82G5
6214B	0686-0335	1	fxd comp 3.3 5% 1/2W	01121	EB33G5
6216B	0686-0335	1	fxd comp 3.3 5% 1/2W	01121	EB33G5
6218B	0686-0335	1	fxd comp 3.3 5% 1/2W	01121	EB33G5
R15-52			NOT ASSIGNED		
R53					
6212B	0757-0280	1	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
6214B	0757-0280	1	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
6216B	0757-0274	1	fxd film 1.21k 1% 1/8W	24546	C4-1/8-T0-1211-F
6218B	0757-0274	1	fxd film 1.21k 1% 1/8W	24546	C4-1/8-T0-1211-F
R54					
6212B	0757-0467	1	fxd film 121k 1% 1/8W	24546	C4-1/8-T0-1213-F
6214B	0698-5088	1	fxd film 12k 1% 1/8W	24546	C4-1/8-T0-1202-F
6216B	0698-5151	1	fxd film 29.9k 1% 1/8W	24546	C4-1/8-T0-2912-F
6218B	0698-3572	1	fxd film 60.4k 1% 1/8W	24546	C4-1/8-T0-6042-F
R55					
6212B	0698-3440	1	fxd film 196 1% 1/8W	24546	C4-1/8-T0-196R-F
6214B	0698-3440	1	fxd film 196 1% 1/8W	24546	C4-1/8-T0-196R-F
6216B	0757-0269	1	fxd film 270 1% 1/8W	24546	C4-1/8-T0-271-F
6218B	0757-0269	1	fxd film 270 1% 1/8W	24546	C4-1/8-T0-271-F
R56			NOT ASSIGNED		
R57					
6212B	0757-0465	1	fxd film 100k 1% 1/8W	24545	C4-1/8-T0-1003-F
6214B	0698-6076	1	fxd film 39k 1% 1/8W	24546	C4-1/8-T0-3902-F
6216B	0698-5089	1	fxd film 33k 1% 1/8W	24546	C4-1/8-T0-3302-F
6218B	0698-5089	1	fxd film 33k 1% 1/8W	24546	C4-1/8-T0-3302-F
S1	3101-1258	1	switch tgl 2A 250Vac	28480	
S2	3101-1363	1	switch sl 0.5A 125Vac/dc	28480	
F1	2110-0012	1	CHASSIS ELECTRICAL fuse 0.5 A, 250 V	28480	
Q1-6			NOT ASSIGNED		
Q7					
6212B	1854-0421	1	NPN Si	28480	
6214B	1854-0225	1	NPN Si	28480	
6216B	1854-0225	1	NPN Si	28480	
6218B	1854-0239	1	NPN Si	28480	
T1					
6212B	9100-2608	1	transformer	28480	
6214B	9100-2610	1	transformer	28480	
6216B	9100-2609	1	transformer	28480	
6218B	9100-2609	1	transformer	28480	

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
			MECHANICAL		
6212B	06212-60020	1		28480	-----
6214B	06214-60020	1	P.C. Board Assembly, Main	28480	-----
6216B	06216-60021	1	(Includes Components)	28480	-----
6218B	06218-60021	1		28480	-----
	0340-0168	2	Insulator Bushing (Q7)	28480	
	0340-0174	1	Insulator (Q7)	28480	
	1200-0181	1	Insulator (Q5)	28480	
	8120-0050	1	Line Cord	28480	
	0400-0013	1	Line Cord Strain Relief	28480	
	2100-0564	1	Fuseholder Body	28480	
	2100-0565	1	Fuseholder Cap	28480	
	2110-0569	1	Fuseholder Nut	28480	
	5020-2579	1	Heatsink	28480	
	0370-0101	2	Black Knob	28480	
	0370-2241	2	Red Knob	28480	
	1510-0094	2	Binding Post	28480	
	1510-0522	1	Binding Post	28480	
	7101-0748	1	Top Cover	28480	
	7101-0749	1	Bottom Cover	28480	
	5001-4968	1	Rear Cover	28480	
	5081-4969	1	with Lettering (115V) Rear Cover, 230V (Option £028)	28480	
			Front Cover with Lettering		
6212B	06212-60004	1		28480	
6214B	06214-60004	1		28480	
6216B	06216-60004	1		28480	
6218B	06218-60004	1		28480	
			Front Panel Assembly		
6212B	06212-60002	1		28480	
6214B	06214-60002	1		28480	
6216B	06216-60002	1		28480	
6218B	06218-60002	1		28480	
			Meters		
6212B	1120-1247	1	2.25A, 120V	28480	
6214B	1120-1133	1	2.25A, 12V	28480	
6216B	1120-1137	1	2.25A, 30V	28480	
6218B	1120-1142	1	2.25A, 60V	28480	
	4040-0934	1	Meter Bezel	28480	
	1460-0256	1	Meter Spring	28480	
	5020-5757	1	A1 Board (Blank)	28480	
	5020-5731	1	A2 Board (Blank)	28480	
			A1 Board with Components		
6212B	06212-60020	1		28480	
6214B	06214-60020	1		28480	
6216B	06216-60020	1		28480	
6218B	06218-60020	1		28480	
			A2 Board with Components		
6212B	06212-60021	1		28480	
6214B	06214-60021	1		28480	
6216B	06216-60021	1		28480	
6218B	06218-60021	1		28480	
	5950-1928	1	Operating & Service Manual	28480	

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
	9211-3319	1	Corrugated Container	28480	
	9220-3212	1	Corrugated Pad	28480	
	9220-3213	2	Foam Pad	28480	
R54					
6212B	0757-0467	1	fxd film 121k 1% 1/8W	24546	C4-1/8-T0-1213-F
6214B	0698-5088	1	fxd film 12k 1% 1/8W	24546	C4-1/8-T0-1202-F
6216B	0698-5151	1	fxd film 29.9k 1% 1/8W	24546	C4-1/8-T0-2912-F
6218B	0698-3572	1	fxd film 60.4k 1% 1/8W	24546	C4-1/8-T0-6042-F
R55					
6212B	0698-3440	1	fxd film 196 1% 1/8W	24546	C4-1/8-T0-196R-F
6214B	0698-3440	1	fxd film 196 1% 1/8W	24546	C4-1/8-T0-196R-F
6216B	0757-0269	1	fxd film 270 1% 1/8W	24546	C4-1/8-T0-271-F
6218B	0757-0269	1	fxd film 270 1% 1/8W	24546	C4-1/8-T0-271-F
R56			NOT ASSIGNED		
R57					
6212B	0757-0465	1	fxd film 100k 1% 1/8W	24545	C4-1/8-T0-1003-F
6214B	0698-6076	1	fxd film 39k 1% 1/8W	24546	C4-1/8-T0-3902-F
6216B	0698-5089	1	fxd film 33k 1% 1/8W	24546	C4-1/8-T0-3302-F
6218B	0698-5089	1	fxd film 33k 1% 1/8W	24546	C4-1/8-T0-3302-F
S1	3101-1258	1	switch tgl 2A 250Vac	28480	
S2	3101-1363	1	switch sl 0.5A 125Vac/dc	28480	
			CHASSIS ELECTRICAL		
F1	2110-0012	1	fuse 0.5 A, 250 V	28480	
F2	2110-0004	1	fuse 0.25 A, 250 V (for use in Option 028 units only)		
Q1-6			NOT ASSIGNED		
Q7					
6212B	1854-0421	1	NPN Si	28480	
6214B	1854-0225	1	NPN Si	28480	
6216B	1854-0225	1	NPN Si	28480	
6218B	1854-0239	1	NPN Si	28480	
T1					
6212B	9100-2608	1	transformer	28480	
6214B	9100-2610	1	transformer	28480	
6216B	9100-2609	1	transformer	28480	
6218B	9100-2609	1	transformer	28480	
			MECHANICAL PARTS		
	0340-0168	2	Insulator Bushing (Q7)	28480	
	0340-0174	1	Insulator (Q7)	28480	
	1200-0181	1	Insulator (Q5)	28480	
	8120-0050	1	Line Cord	28480	
	0400-0013	1	Line Cord Strain Relief	28480	
	2100-0564	1	Fuseholder Body	28480	
	2100-0565	1	Fuseholder Cap	28480	
	2110-0569	1	Fuseholder Nut	28480	
	5020-2579	1	Heatsink	28480	
	0370-0101	2	Black Knob	28480	
	0370-2241	2	Red Knob	28480	
	1510-0094	2	Binding Post	28480	
	1510-0522	1	Binding Post	28480	
	7101-0748	1	Top Cover	28480	
	7101-0749	1	Bottom Cover	28480	
	5081-4968	1	Rear Cover	28480	
			with Lettering (115V)		
	5081-4969	1	Rear Cover, 230V (Option 028)	28480	

Table 6-4. 621B/14B/16B/18B/ Parts List (cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
6212B 6214B 6216B 6218B	06212-60004 06214-60004 06216-60004 06218-60004	1 1 1 1	Front Cover with Lettering	28480 28480 28480 28480	
6212B 6214B 6216B 6218B	06212-60002 06214-60002 06216-60002 06218-60002	1 1 1 1	Front Panel Assembly	28480 28480 28480 28480	
6212B 6214B 6216B 6218B	1120-1247 1120-1133 1120-1137 1120-1142	1 1 1 1	Meters 2.25A, 120V 2.25A, 12V 2.25A, 30V 2.25A, 60V	28480 28480 28480 28480	
	4040-0934 1460-0256 5020-5757 5020-5731	1 1 1 1	Meter Bezel Meter Spring A1 Board (Blank) A2 Board (Blank)	28480 28480 28480 28480	
6212B 6214B 6216B 6218B	06212-60020 06214-60020 06216-60020 06218-60020	1 1 1 1	A1 Board with Components	28480 28480 28480 28480	
6212B 6214B 6216B 6218B	06212-60021 06214-60021 06216-60021 06218-60021	1 1 1 1	A2 Board with Components	28480 28480 28480 28480	
	5950-1928 9211-3319 9220-3212 9220-3213	1 1 1 2	Operating & Service Manual Corrugated Container Corrugated Pad Foam Pad	28480 28480 28480 28480	

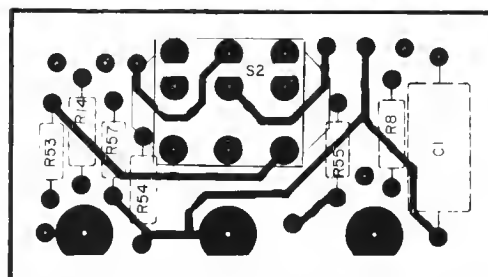
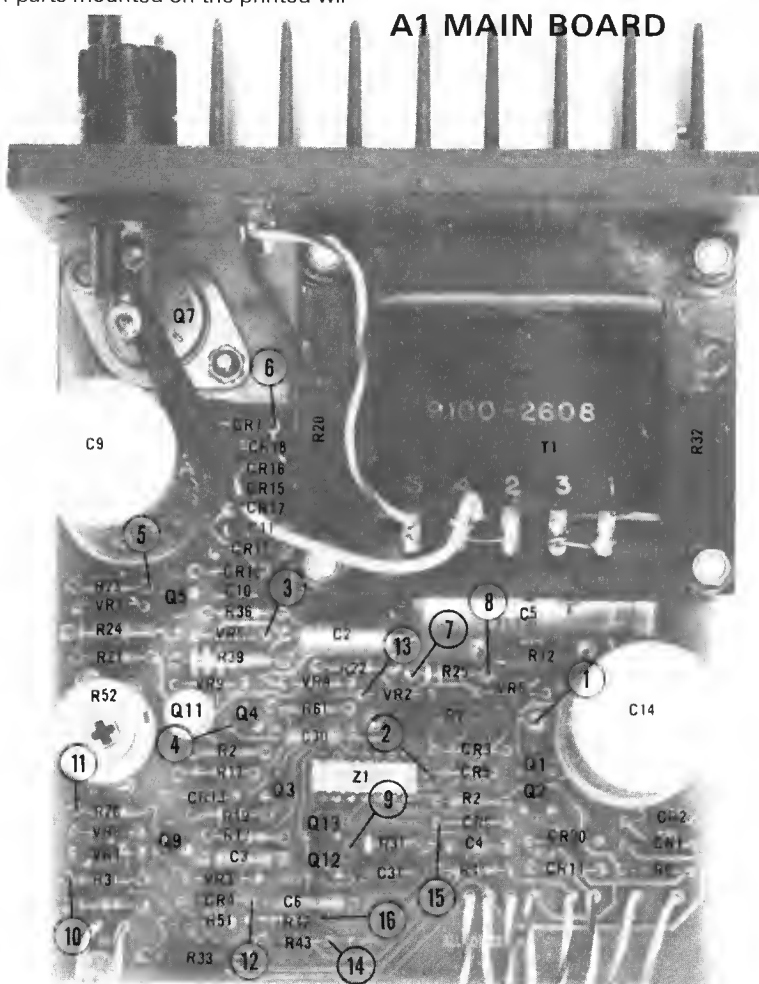
## Section VII CIRCUIT DIAGRAMS

This section contains the circuit diagrams necessary for the operation and maintenance of these power supplies. Included are:

- a. Component Location Diagram, Figure 7-1 and 7-2 show the physical location and reference designator of parts mounted on the printed wiring

ing board.

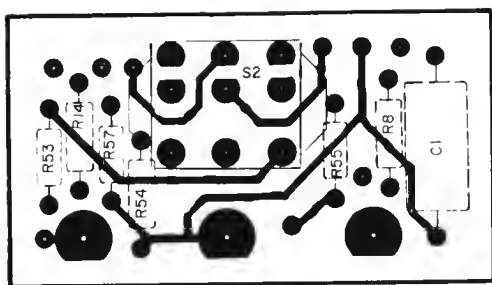
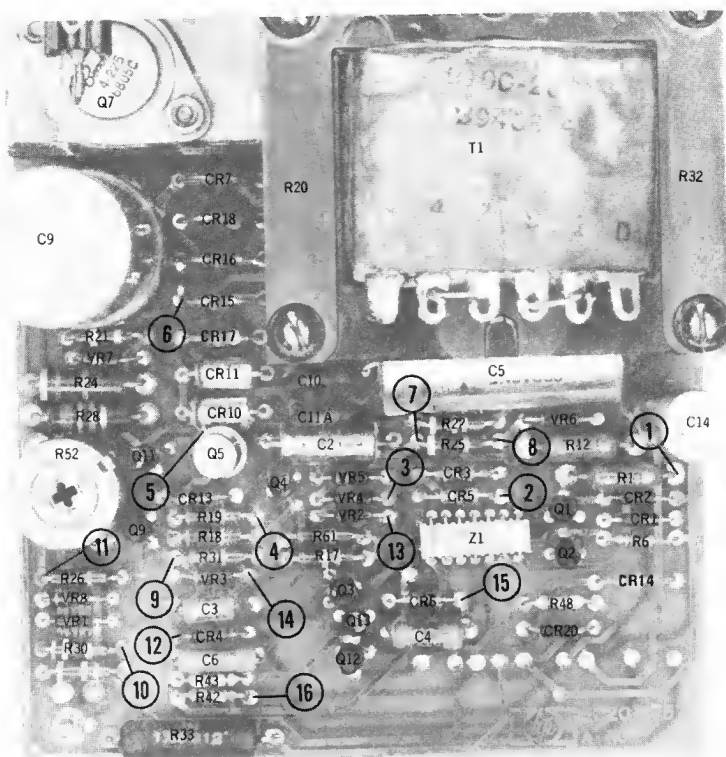
- b. Schematic Diagram, figure 7-3, which illustrates the circuitry for the entire power supply. Voltages are given adjacent to test points, identified by encircled numbers on the schematic and printed wiring board.



**A2 FRONT PANEL BOARD  
(rear view)**

**Figure 7-1. Component Location Diagram Model 6212B**

## A1 MAIN BOARD



**A2 FRONT PANEL BOARD**  
(rear view)



**Figure 7-2. Component Location Diagram. Models 6214B, 6216B, 6218B**



\*COMPONENT VALUE TABLE.

COMPONENT	MODELS			
	6212B	6214B	6216B	6218B
C1	5 $\mu$ F 150 V	5 $\mu$ F 50 V	5 $\mu$ F 65 V	5 $\mu$ F 65 V
C3	.0047 $\mu$ F 10%	.0068 $\mu$ F 10%	.0068 $\mu$ F 10%	.0047 $\mu$ F
C4	.001 $\mu$ F 10%	.0047 $\mu$ F 10%	.0047 $\mu$ F 10%	.0047 $\mu$ F 10%
C15	Not Used	3.3 $\mu$ F $\pm$ 10% 50 V	3.3 $\mu$ F $\pm$ 10% 50 V	5 $\mu$ F + 75 - 10% 65 V
R1	3 k $\pm$ 5% 5 W	1 k $\pm$ 3% 3 W	1 k $\pm$ 5% 3 W	1 k $\pm$ 5% 3 W
R6	4.75 k 1%	1.5 k 1%	1.5 k 1%	1.5 k 1%
R8	75 5%	24 5%	24 5%	24 5%
R10A	22 k - 200	5 k - 50	5 k - 50	5 k - 50
R10B	22 k - 200	5 k - 50	5 k - 50	5 k - 50
R11A	5 k - 50	5 k - 50	10 k - 100	5 k - 50
R11B	5 k - 50	5 k - 50	10 k - 100	5 k - 50
R12	1124 $\pm$ .1% 125 W	2.6 k $\pm$ 5% 3 W	1 k $\pm$ 5% 3 W	1.1 k $\pm$ 5% 3 W
R14	8.2 k 5% .5 W	3.3 5% .5 W	3.3 5% .5 W	3.3 5% .5 W
R17	12 k 5% .5 W	6.2 k 5% .5 W	7.5 k 5% .5 W	6.8 k 5% .5 W
R19	10 k 5% .5 W	1 k 5% .5 W	1 k 5% .5 W	1 k 5% .5 W
R20	820 5% 3 W	820 5% 3 W	2 k 5% 2 W	2 k 5% 2 W
R21	220 5% .5 W	240 5% .5 W	240 5% .5 W	220 5% .5 W
R22	56 k 5% .5 W	30 k 5% .5 W	30 k 5% .5 W	30 k 5% .5 W
R26	150 5% .5 W	200 5% .5 W	200 5% .5 W	200 5% .5 W
R28	2 k 5% .5 W	820 5% .5 W	820 5% .5 W	820 5% .5 W
R30	680 5% .5 W	390 5% .5 W	1.8 k 5% .5 W	1.8 k 5% .5 W
R31	1 k 5% .5 W	820 5% .5 W	1 k 5% .5 W	1 k 5% .5 W
R33	10 5% 3 W	1 5% 5 W	3 5% 3 W	6 5% 3 W
R42	23 k 1% .125 W	23 k 1% .125 W	45 k 1% .125 W	45 k 1% .125 W
R52	500 10%	250 20%	250 20%	250 20%
R53	1 k 1% .125 W	1k 1% .125 W	1.2 k 1% .125 W	1.2 k 1% .125 W
R54	121 k 1% .125 W	12 k 1% .125 W	29.9 k 1% .125 W	60.4 k 1% .125 W
R55	196 1% .125 W	196 1% .125 W	270 1% .125 W	270 1% .125 W
R57	100 k 1% .125 W	39 k 1% .125 W	33 k 1% .125 W	33 k 1% .125 W

NOTES:

- All resistors are 1/2 W, 5% unless otherwise specified.
- All 1/8 and 1/4 watt resistors are 1%, 100 ppm.
- 220 ppm wire temperature coefficient.
- Meter switch, S2, as viewed from rear. Shown in voltage position.
-  Denotes voltage feedback signal.
-  Denotes current feedback signal.
- Transformer shown strapped for 115 V operation. See instruction manual for 220 Vac.
- DC voltages were measured under the following conditions:
  - Hewlett Packard voltmeter Model 3456A or 3466A or equivalent.
  - 115 Vac input.
  - Voltages referenced to + S unless otherwise noted.
  - Voltages are typical,  $\pm$  10%, unless otherwise noted.
  - All readings taken in constant voltage operation at maximum rated output with no load connected and current control turned fully clockwise.
- Main supply output voltages are:
 

MODEL	VDC
6212B	150
6214B	22
6216B	44
6218B	78
- Connect to proper pin number, see chart below.

MODEL	T1 SECONDARY PIN NO.s	
	8	9
6212B	✓	
6214B		✓
6216B	(See Inset)	
6218B	✓	

- This circuit is used in Model 6212B only. When in use delete the lines that connect points A and B and point C with test point (5)

## ANDOLA

Telectra  
Empresa Técnica de Equipamentos  
Elétricos, S.A.R.L.  
R. Barbosa Rodrigues,  
41-11<sup>th</sup> F.  
Caxa Postal, 6487  
Lusanda  
Tel: 35515/56  
Telex: 355155/56  
**ARGENTINA**  
Hewlett-Packard Argentina S.A.  
Santa Fe 2035, Martinez  
8140 Buenos Aires  
Tel: 762 1239 798-6086  
Telex: 122443 AR CIGY  
Biotron S A C i y M  
Ave. Paseo Colon 221  
9 piso  
1359 Buenos Aires  
Tel: 30 4848/185 10384  
34 9355/0460/4551  
Telex: (33) 17595 BI AR

## AUSTRALIA

**AUSTRALIA CAPITAL TERR.**  
Hewlett-Packard Australia Pty Ltd  
121 Wollongong Street  
Fyshwick, 2609  
Tel: 804244  
Telex: 62550

## NEW SOUTH WALES

Hewlett-Packard Australia Pty Ltd  
31 Bridge Street  
Pymbla, 2073  
Tel: 449566  
Telex: 21861

## QUEENSLAND

Hewlett-Packard Australia Pty Ltd  
5th Floor  
Teachers Union Building  
495-499 Boundary Street  
Spring Hill, 4000  
Tel: 2291544

## SOUTH AUSTRALIA

Hewlett-Packard Australia Pty Ltd  
153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## VICTORIA

Hewlett-Packard Australia Pty Ltd  
31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## WESTERN AUSTRALIA

Hewlett-Packard Australia Pty Ltd  
141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## AUSTRIA

Hewlett-Packard Ges.m.b.H.  
Wehrstrasse 29  
P.O. Box 7  
A-1205 Wien  
Tel: 5126 11-21  
Telex: 135862/135066

## Hewlett-Packard Ges.m.b.H.

Wehrstrasse 29  
P.O. Box 648  
Bahrain  
Tel: 54086, 56123  
Telex: 8550 WAEL GJ

## ALGERIA

Al Hemydia Trading and Contracting  
P.O. Box 20074  
Marrakech  
Tel: 259278, 259958  
Telex: 8895 KALDA GI

## BANGLADESH

The General Electric Co. of Bangladesh Ltd.  
Maguel House 72  
Dhaka Commercial Area  
Motihalli, Dacca 2  
Tel: 252415, 252419  
Telex: 734

## BELGIUM

Hewlett-Packard Benelux S.A.  
A.N.V.  
Avenue du Col Vert, 1  
(Groenkraslaan)  
B-1170 Brussels  
Tel: (02) 660 50 50  
Telex: 23 494 pauben BR

## BRAZIL

Hewlett-Packard do Brasil  
L.E. Ltda.  
Alameda Rio Negro, 750  
Alphaville  
06400 Barueri SP  
Tel: 429-3222  
Hewlett-Packard do Brasil  
L.E. Ltda.  
Rua Pacifico Otago, 32  
90000-010 Alpha RG RS  
Tel: 22-2998, 22-5621  
Hewlett-Packard do Brasil  
L.E. Ltda.  
Av. Eplacio Pessoa, 4664  
22471 Rio de Janeiro RJ  
Tel: 286-0237  
Telex: 021-1905 HPRB-BR

## CANADA

**ALBERTA**  
Hewlett-Packard (Canada) Ltd  
11620A - 168th Street  
Edmonton T5M 3T9  
Tel: (403) 452-3870  
Telex: 610 831 2431  
**ONTARIO**  
Hewlett-Packard (Canada) Ltd  
210, 7220 Fisher St. S.E.  
Calgary T2H 2H8  
Tel: (403) 253-2713  
Telex: 93229  
TWX 610-821-6141

## BRITISH COLUMBIA

Hewlett-Packard (Canada) Ltd  
11601 Shellbridge Way  
Richmond V6X 2W7  
Tel: (604) 270-2277  
TWX 610-925-5059

## MANITOBA

Hewlett-Packard (Canada) Ltd  
380 550 Century St.  
St. James  
Winnipeg R3J 0Y1  
Tel: (204) 786-3511  
TWX 610-671-3531

## NEW SCOTIA

Hewlett-Packard (Canada) Ltd  
400 Windmill Road  
Dartmouth B3B 1L1  
Tel: (902) 469-7820  
TWX 610-271-4482

## ONTARIO

Hewlett-Packard (Canada) Ltd  
1020 Morrison Dr.  
Ottawa K2H 8K3  
Tel: (613) 820-6483  
Telex: 610-563-1636

## Hewlett-Packard (Canada) Ltd

6877 Goreway Drive  
Mississauga L4V 1M8  
Tel: (416) 678-9430  
TWX 610-492-4246

## Hewlett-Packard (Canada) Ltd

552 Herbold Street  
Dorval H9S 2S5  
Tel: (514) 897-4322  
TWX 610-422-3022

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

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141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
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Tel: 2725911  
Telex: 82536

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31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

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Nedlands, 6009  
Tel: 9385959  
Telex: 93859

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Tel: 2725911  
Telex: 82536

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31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## CYPRUS

Kypricos  
19 Gregorios Xenopoulos  
Street  
Tel: (40) 59 41 02  
Telex: 510770  
**NICOLA**  
Tel: 45628-29  
Telex: 3018

## CZECHOSLOVAKIA

Hewlett-Packard  
Obchodní zastupitelství v CSR  
Plesmý 4/IV  
Post. schránka 27  
CS 118 01 Praha 011  
CSR

## Hewlett-Packard (Canada) Ltd

Av. Eplacio Pessoa, 4664  
22471 Rio de Janeiro RJ  
Tel: 286-0237  
Telex: 021-1905 HPRB-BR

## CANADA

**ALBERTA**  
Hewlett-Packard (Canada) Ltd  
11620A - 168th Street  
Edmonton T5M 3T9  
Tel: (403) 452-3870  
Telex: 610 831 2431

## BRITISH COLUMBIA

Hewlett-Packard (Canada) Ltd  
11601 Shellbridge Way  
Richmond V6X 2W7  
Tel: (604) 270-2277  
TWX 610-925-5059

## MANITOBA

Hewlett-Packard (Canada) Ltd  
380 550 Century St.  
St. James  
Winnipeg R3J 0Y1  
Tel: (204) 786-3511  
TWX 610-671-3531

## NEW SCOTIA

Hewlett-Packard (Canada) Ltd  
400 Windmill Road  
Dartmouth B3B 1L1  
Tel: (902) 469-7820  
TWX 610-271-4482

## ONTARIO

Hewlett-Packard (Canada) Ltd  
1020 Morrison Dr.  
Ottawa K2H 8K3  
Tel: (613) 820-6483  
Telex: 610-563-1636

## Hewlett-Packard (Canada) Ltd

6877 Goreway Drive  
Mississauga L4V 1M8  
Tel: (416) 678-9430  
TWX 610-492-4246

## Hewlett-Packard (Canada) Ltd

552 Herbold Street  
Dorval H9S 2S5  
Tel: (514) 897-4322  
TWX 610-422-3022

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

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141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

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153 Greenhill Road  
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Telex: 82536

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Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

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153 Greenhill Road  
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Tel: 2725911  
Telex: 82536

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31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

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141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

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Tel: 2725911  
Telex: 82536

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31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

Hewlett-Packard France  
Le Ligures  
Place Romée de Villeneuve  
13100 Aix-en-Provence  
Tel: (40) 59 41 02  
Telex: 510770  
**NICOLA**  
Tel: 45628-29  
Telex: 3018

## CZECHOSLOVAKIA

Hewlett-Packard  
Obchodní zastupitelství v CSR  
Plesmý 4/IV  
Post. schránka 27  
CS 118 01 Praha 011  
CSR

## Hewlett-Packard (Canada) Ltd

Av. Eplacio Pessoa, 4664  
22471 Rio de Janeiro RJ  
Tel: 286-0237  
Telex: 021-1905 HPRB-BR

## CANADA

**ALBERTA**  
Hewlett-Packard (Canada) Ltd  
11620A - 168th Street  
Edmonton T5M 3T9  
Tel: (403) 452-3870  
Telex: 610 831 2431

## BRITISH COLUMBIA

Hewlett-Packard (Canada) Ltd  
11601 Shellbridge Way  
Richmond V6X 2W7  
Tel: (604) 270-2277  
TWX 610-925-5059

## MANITOBA

Hewlett-Packard (Canada) Ltd  
380 550 Century St.  
St. James  
Winnipeg R3J 0Y1  
Tel: (204) 786-3511  
TWX 610-671-3531

## NEW SCOTIA

Hewlett-Packard (Canada) Ltd  
400 Windmill Road  
Dartmouth B3B 1L1  
Tel: (902) 469-7820  
TWX 610-271-4482

## ONTARIO

Hewlett-Packard (Canada) Ltd  
1020 Morrison Dr.  
Ottawa K2H 8K3  
Tel: (613) 820-6483  
Telex: 610-563-1636

## Hewlett-Packard (Canada) Ltd

6877 Goreway Drive  
Mississauga L4V 1M8  
Tel: (416) 678-9430  
TWX 610-492-4246

## Hewlett-Packard (Canada) Ltd

552 Herbold Street  
Dorval H9S 2S5  
Tel: (514) 897-4322  
TWX 610-422-3022

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

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141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

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Blackburn, 3130  
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Telex: 31024 MELB

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Nedlands, 6009  
Tel: 9385959  
Telex: 93859

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Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

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Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
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Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## GUAM

Guam Medical Supply, Inc.  
Suite C, Airport Plaza  
P.O. Box 8947  
Tumoning 96911  
Tel: 646-4513

## QUATMALA

ipSA  
Avenida Reforma 3-48  
Zona 9  
Guatemala City  
Tel: 216627, 314786,  
66471-5, ext. 9  
Telex: 4192 Teletro GU

## Hewlett-Packard (Canada) Ltd

Av. Eplacio Pessoa, 4664  
22471 Rio de Janeiro RJ  
Tel: 286-0237  
Telex: 021-1905 HPRB-BR

## CANADA

**ALBERTA**  
Hewlett-Packard (Canada) Ltd  
11620A - 168th Street  
Edmonton T5M 3T9  
Tel: (403) 452-3870  
Telex: 610 831 2431

## BRITISH COLUMBIA

Hewlett-Packard (Canada) Ltd  
11601 Shellbridge Way  
Richmond V6X 2W7  
Tel: (604) 270-2277  
TWX 610-925-5059

## MANITOBA

Hewlett-Packard (Canada) Ltd  
380 550 Century St.  
St. James  
Winnipeg R3J 0Y1  
Tel: (204) 786-3511  
TWX 610-671-3531

## NEW SCOTIA

Hewlett-Packard (Canada) Ltd  
400 Windmill Road  
Dartmouth B3B 1L1  
Tel: (902) 469-7820  
TWX 610-271-4482

## ONTARIO

Hewlett-Packard (Canada) Ltd  
1020 Morrison Dr.  
Ottawa K2H 8K3  
Tel: (613) 820-6483  
Telex: 610-563-1636

## Hewlett-Packard (Canada) Ltd

6877 Goreway Drive  
Mississauga L4V 1M8  
Tel: (416) 678-9430  
TWX 610-492-4246

## Hewlett-Packard (Canada) Ltd

552 Herbold Street  
Dorval H9S 2S5  
Tel: (514) 897-4322  
TWX 610-422-3022

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

141 Sirling Highway  
Nedlands, 6009  
Tel: 9385959  
Telex: 93859

## Hewlett-Packard (Canada) Ltd

153 Greenhill Road  
Parkdale, 5063  
Tel: 2725911  
Telex: 82536

## Hewlett-Packard (Canada) Ltd

31-41 Joseph Street  
Blackburn, 3130  
Tel: 89 6351  
Telex: 31024 MELB

## Hewlett-Packard (Canada) Ltd

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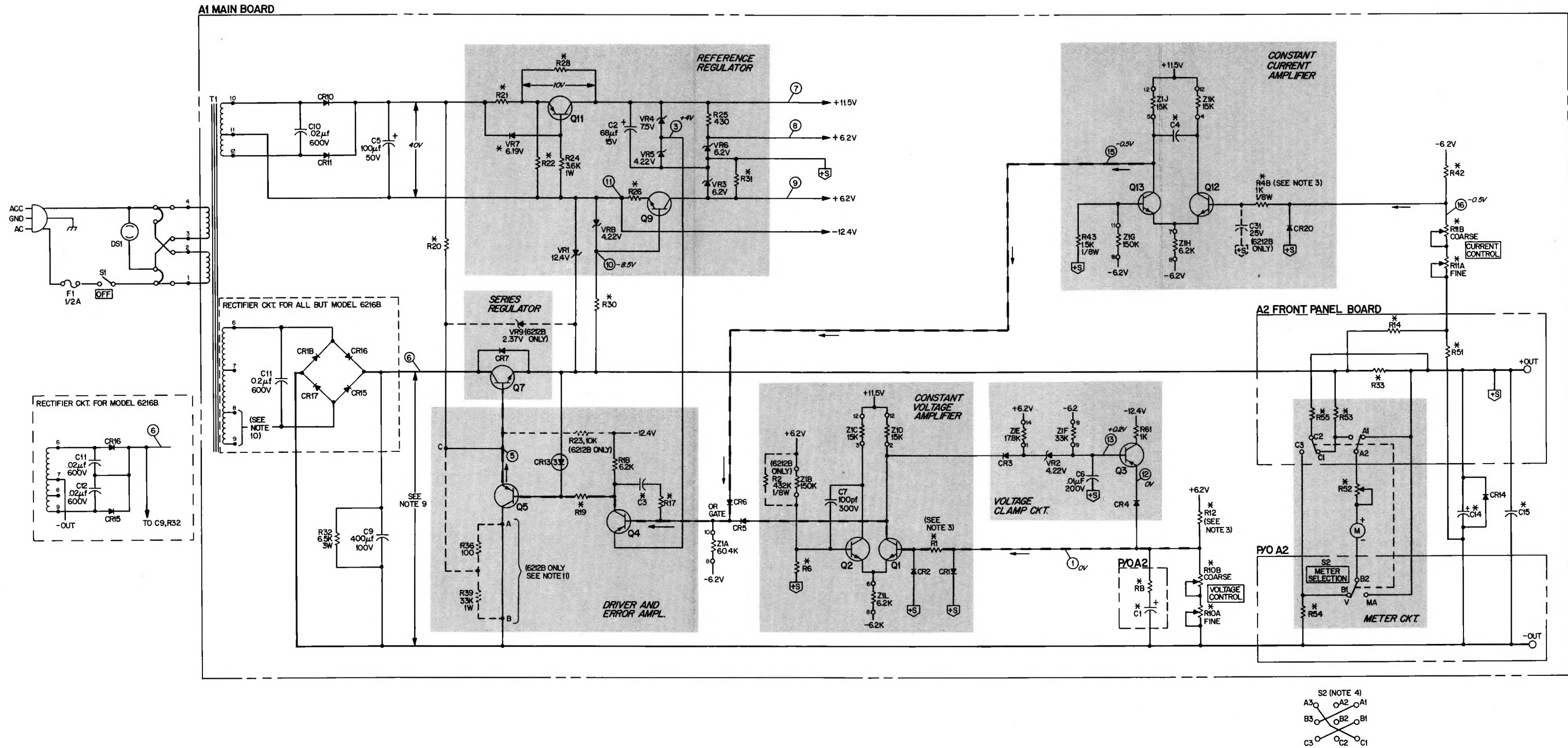


Figure 7-3. Schematic Diagram.



## Manual Part No. 5950-1929

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
ALL		Errata

On page 1-2 under Transient Recovery Time, change the end of the sentence to read; "... following a change in output current equal to half the current rating of the supply.

On page 5-6, paragraph 5-37, letter c., change the end of the sentence to read; "... panel meter indicates exactly half the maximum rated output current.

On page 5-3, paragraph 5-16, letter f., change the end of the sentence to read: "... recorded in step d. by more than 4mVdc, (8mVdc, 6212B).

In the replaceable parts list, Table 6-4 should read; 6212B/14B/16B/18B Parts List.

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